Aeroplane Maintenance and Operation Series, Volume 19

AUXILIARY EQUIPMENT

AEROPLANE MAINTENANCE AND OPERATION SERIES

Compiled under the General Editorship of E. MOLLOY

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Aeroplane Maintenance and Operation Series, Volume 19

AUXILIARY EQUIPMENT

DEALING WITH FIRE-EXTINGUISHING EQUIPMENT, CARE AND MAINTENANCE OF BATTERIES AND SPARKING PLUGS, IGNITION SCREENING HARNESS, DE-ICING EQUIPMENT, AND THE MAINTENANCE OF PARACHUTES

General Editor
E. MOLLOY

Advisory Editor
E. W. KNOTT, M.I.A.E., M.S.A.E.

COMPILED BY A PANEL OF EXPERTS

WITH
ONE HUNDRED AND FOUR
ILLUSTRATIONS

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PREFACE

THE construction of a modern aeroplane can be conveniently divided under: Engines, Airframes, Airscrews, Electrical Equipment, Instruments, and Auxiliary Equipment.

Previous volumes in this series have dealt with some outstanding types under each of these headings, with the exception of the last.

The present volume is devoted to this important subject of auxiliary equipment.

Two of the main Fire Extinguishing Systems, namely, the Lux and Essex, have first been treated. After this will be found a section dealing with the installation and maintenance of secondary batteries or accumulators.

In the aeroplane, as in the car, the battery is a component which, owing to the entire absence of moving parts, is liable to be overlooked when the questions of servicing and maintenance are under consideration. Regular attention to the batteries is, however, a vital necessity, if they are to retain their efficiency unimpaired. The simple, but necessary, servicing instructions will be found in the section which begins on page 25.

Other electrical components which, whilst vital to the effective operation of the engine, depend for their efficiency upon careful and systematic servicing, are the sparking plugs.

Notes on Testing, Dismantling and General Maintenance, will be found in the section which begins on page 56.

It is obvious that in view of the fact that radio communication is so widely used on modern aircraft, electrical interference will occur, due to the operation of the sparking plugs, unless special precautions are taken.

The ignition screening harness has been designed to eliminate any such interference at its source. Practical notes on the ignition screening harness, including inspection and tests, are given in the section which begins on page 33.

De-icing equipment forms the subject of a later section, in which the Dunlop De-icer and the Goodrich De-icer are dealt with from the point of view of operation and maintenance.

Particular attention is directed to the notes which are contained at the end of this section, dealing with the subject of airscrew protection.

The efficacy of the modern parachute is now established beyond question. This efficiency depends to a very large extent upon the initial care which is given to the scientific packing of the parachute in its container. It is for this reason that the subject of the packing operation, as applied to the Irvin and the G.Q. parachutes, forms a substantial section of the general article on this subject.

Notes on Inspection, Maintenance and Repair provide an interesting conclusion to the section devoted to this important subject.

We take this opportunity to thank the following firms for the valuable assistance which they have afforded us in connection with this book :

Walter Kidde Co., Ltd.
National Fire Protection Co.
Peto & Radford, Ltd.
Technical Improvements, Ltd.
Smiths Aircraft Instruments.
British Tyre and Rubber Co., Ltd.
Lockheed Aircraft Corporation.

It is hoped that the bringing together of so much technical data relating to aircraft auxiliaries, in a form convenient for ready reference, will be appreciated by ground engineers, aircraftsmen, and others responsible for maintaining air-borne craft in the high state of efficiency which present-day conditions demand.

E. W. K.
E. M.

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AUXILIARY EQUIPMENT

THE "LUX" FIRE EXTINGUISHING SYSTEM

THE " Lux " Fire Extinguishing System is a device which provides the means of extinguishing an engine fire on an aeroplane when it is in flight or on the ground. In general, it consists of an adequate supply of " Lux " gas, stored in a specially machined lightweight steel cylinder which is fitted with a disc valve for retaining the gas ; a spring-actuated cutter valve for releasing the gas ; a piping (tube) system for conducting the gas ; and a control handle for the manual operation of the system.

On twin- and multi-engined aeroplanes a distributing cock is provided for the purpose of directing the flow of gas to the engine afire. The piping is terminated in specially perforated tubing and carburettor nozzle, which serve to eject and distribute the gas effectively about the engine afire.

Typical Arrangement

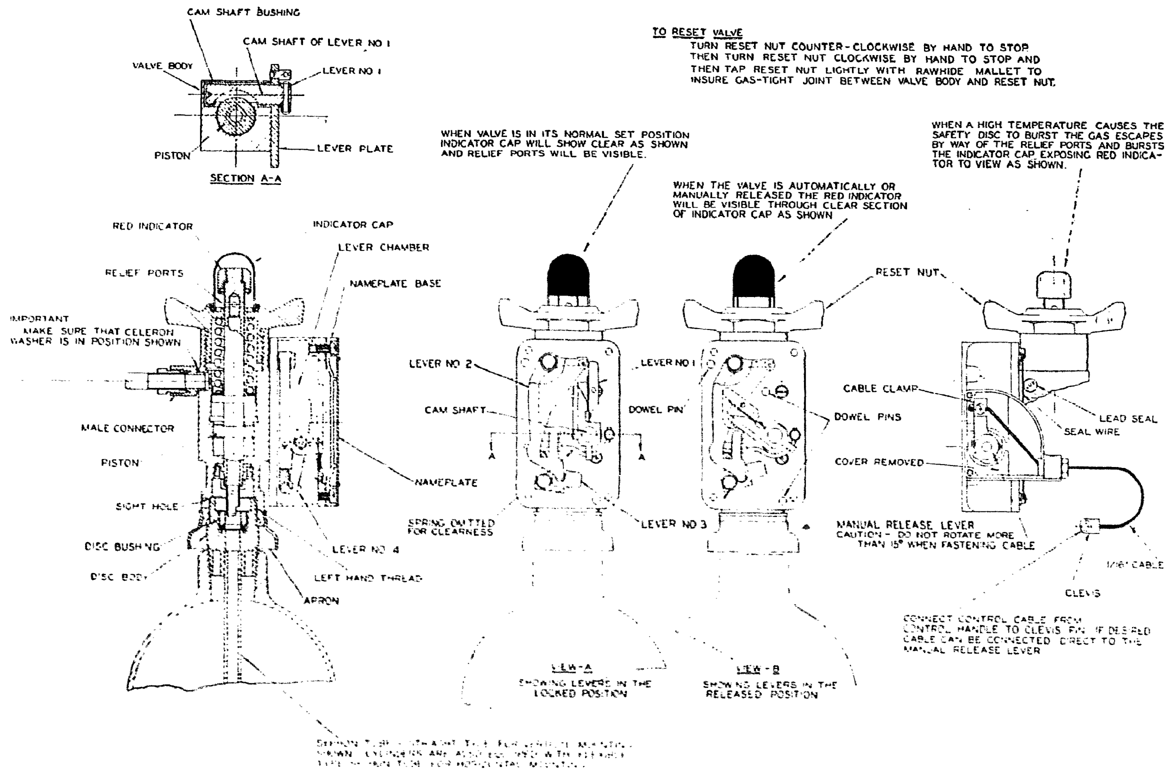
A typical arrangement of the system for single-, twin-, and three-engined aeroplanes is shown in Figs. 2, 3, and 4 respectively.

The " Lux " cylinder is equipped with a disc body containing a sealing-disc bushing and a siphon tube (either a straight tube extending to the bottom of the cylinder, or a short flexible type, depending upon equipment used). The sealing disc also acts as a safety disc, which will release the gas at a pressure attained when a temperature of about 130° F. (54·4° C.) is reached. Care must be taken, therefore, to keep the temperature of the charged cylinder below 130° F. in order to avoid loss of gas through a premature discharge.

Cutter Valve

The cutter valve (Fig. 1) is screwed directly on to the disc body, and consists, briefly, of a spring-actuated tubular cutter and a system of locked levers which retain the actuating spring in its compressed position. The levers are arranged so that they will release the spring when the

T. 1



TO RESET VALVE
TURN RESET NUT COUNTER-CLOCKWISE BY HAND TO STOP
THEN TURN RESET NUT CLOCKWISE BY HAND TO STOP AND
THEN TAP RESET NUT LIGHTLY WITH RAWHIDE MALLET TO
INSURE GAS-TIGHT JOINT BETWEEN VALVE BODY AND RESET NUT.

WHEN VALVE IS IN ITS NORMAL SET POSITION INDICATOR CAP WILL SHOW CLEAR AS SHOWN AND RELIEF PORTS WILL BE VISIBLE.

WHEN THE VALVE IS AUTOMATICALLY OR MANUALLY RELEASED THE RED INDICATOR WILL BE VISIBLE THROUGH CLEAR SECTION OF INDICATOR CAP AS SHOWN

WHEN A HIGH TEMPERATURE CAUSES THE SAFETY DISC TO BURST THE GAS ESCAPES BY WAY OF THE RELIEF PORTS AND BURSTS THE INDICATOR CAP EXPOSING RED INDICATOR TO VIEW AS SHOWN.

IMPORTANT
MAKE SURE THAT CELERON WASHER IS IN POSITION SHOWN

MANUAL RELEASE LEVER
CAUTION - DO NOT ROTATE MORE THAN 15° WHEN FASTENING CABLE

CONNECT CONTROL CABLE FROM CONTROL HANDLE TO CLEVIS PIN. IF DESIRED CABLE CAN BE CONNECTED DIRECT TO THE MANUAL RELEASE LEVER

SIPHON TUBE – STRAIGHT TUBE FOR VERTICAL MOUNTING SHOWN. CYLINDERS ARE ALSO EQUIPPED WITH FLEXIBLE TYPE SIPHON TUBE FOR HORIZONTAL MOUNTING.

Fig. 1.—DETAILS OF CUTTER VALVE FOR MODELS WITHOUT PREFIX "S" manual release lever is rotated (this is accomplished by pulling the control handle which is connected to the manual release lever by means of a flexible cable). When the spring is released, it forces the tubular cutter through the disc, thus releasing the "Lux" gas.

Indicator

A red indicator is provided above the wing nut, and a celluloid cap is placed over this indicator. The celluloid cap is such that when the cutter valve is in its normal, set position, the red indicator is covered from sight. Upon the operation of the system, the indicator travels downward, bringing the red indicator into view, thereby giving a visual indication that the cylinder has been discharged.

Should a high temperature cause the safety disc to burst, the design of the valve is such that the red indicator would remain in its set position and the "Lux" gas would be vented through the relief ports in the stem of the red indicator, thereby bursting the celluloid cap (exposing the red indicator to view, thus indicating that the cylinder has been discharged prematurely) and escaping out into the atmosphere. In this manner, the "Lux" gas will not be discharged about the engine and carburettor upon the release of "Lux" gas due to high temperature.

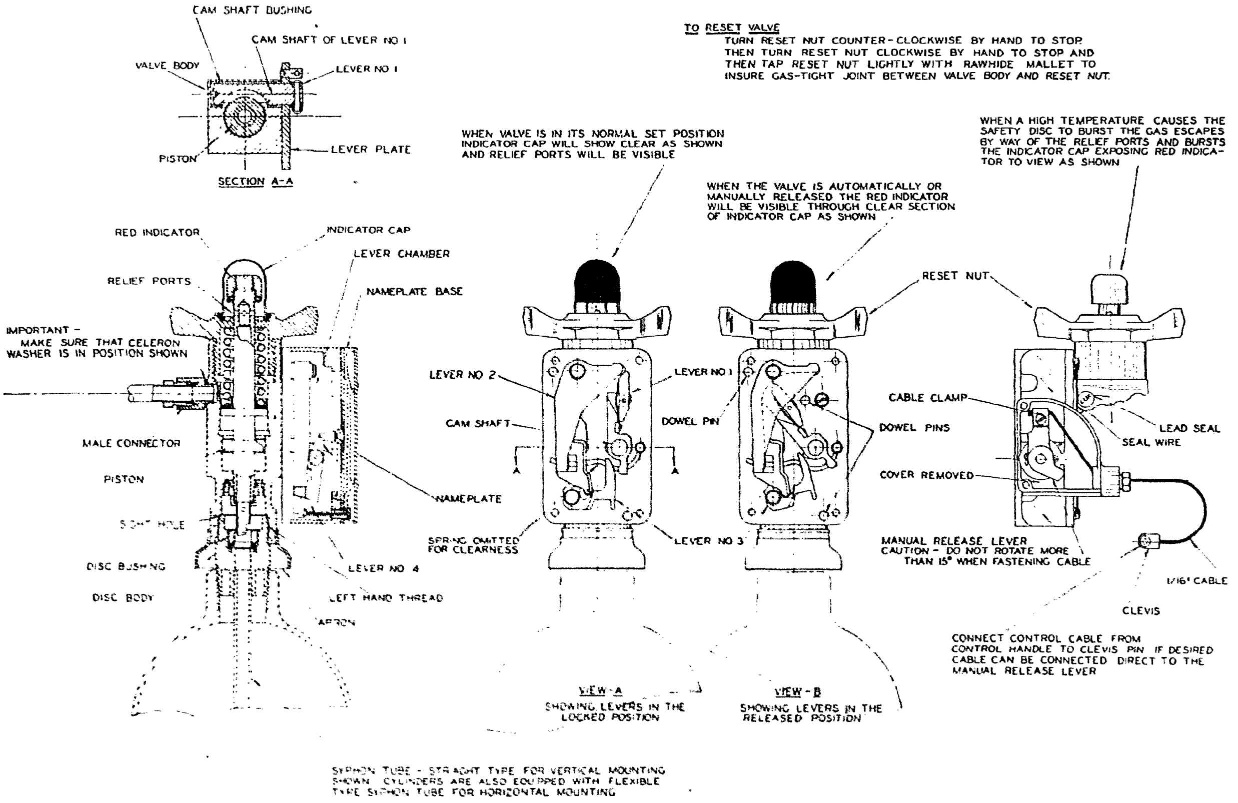
Control Handle

The control handle for the manual operation of the system may be located either on the instrument board or directly on the cutter valve. The latter type of control handle is used only when the cylinder is installed in the pilot's cockpit and within easy direct reach of the pilot. The control handle is connected to the control cable which runs through the cable tubing (no control tubing is used when the control handle is mounted directly on the cutter valve) to the manual release lever.

When the control handle is pulled, it rotates the manual release lever at the valve, thereby releasing the locked levers and tripping the valve. The "Lux" gas then flows out through the supply tubing to the engine afire, where it is distributed by means of the perforated tubing and carburettor nozzle. On twin- and multi-engined aeroplanes, a distributing cock is installed in the supply tubing properly to direct the flow of gas to the engine afire.

GENERAL INSTALLATION

We give details of the method of installing the "Lux" Fire Extinguishing System on an aeroplane that is in actual service. If the system is to be installed at the time the aeroplane is being built, the order of installation can be arranged to suit the various conditions that exist. However, all the points covered by the following text must be observed in order to ensure the proper operation of the system.



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VIEW-A
SHOWING LEVERS IN THE LOCKED POSITION

VIEW-B
SHOWING LEVERS IN THE RELEASED POSITION

SYPHON TUBE – STRAIGHT TYPE FOR VERTICAL MOUNTING SHOWN. CYLINDERS ARE ALSO EQUIPPED WITH FLEXIBLE TYPE SYPHON TUBE FOR HORIZONTAL MOUNTING

Fig. 1A.—DETAILS OF CUTTER VALVE FOR MODELS WITH PREFIX "S"

(1) Installing Cylinder and Cutter Valve

The cylinder may be mounted anywhere on the aeroplane except on the engine side of the fire bulkhead. In selecting the cylinder location, one factor to bear in mind is that the control-cable tubing should be as short, and have as few bends, as possible. Also, the necessary gas supply tubing is to be as direct as possible.

Care should also be taken in the selection of the cylinder location so that the cylinder will not be subjected to a temperature in excess of 130° F. (54·4° C.) in order to avoid loss of gas through a premature discharge.

When the cutter valve is of the type that has the control handle for the manual operation of the system mounted directly on to it, as shown in Fig. 11, the cylinder must be installed in the pilot's cockpit, within easy direct reach of the pilot. Also, it is to be installed where it is easily visible.

Vertical Cylinders

All cylinders that are to be mounted vertically are equipped with a straight siphon tube. This type of cylinder must be mounted either vertically to the thrust line or it may be tilted, provided that an angle of 30° from any side of the vertical position is not exceeded. The vertical position is preferred (see Fig. 5).

Horizontal Cylinders

All cylinders that are to be mounted horizontally are equipped with a "short flexible" siphon tube. This type of cylinder must be mounted horizontally and parallel with the thrust line, with the valve end aft and down, and may be tilted to 30° below the thrust line with the valve end aft and down. The position with the valve end aft and down below the thrust line is preferred (see Fig. 6).

All the positions described above are understood to be with the aeroplane in a two-point position.

Cylinder Markings

In order readily to identify the type of siphon tube furnished with each cylinder, the following markings are stamped on the main body bushing of each cylinder :

"S" means that the cylinder is equipped with a "straight" rigid siphon tube that extends from the disc body to the bottom of the cylinder. A black dot 2 in. in diameter is painted on the bottom, as shown in Fig. 5, as a further identification.

"SF" means that the cylinder is equipped with a "short flexible" siphon tube that extends only from the disc body to the end of the upper spherical portion of the cylinder. A black band 2 in. wide is painted around the cylinder, as shown in Fig. 6, as a further identification.

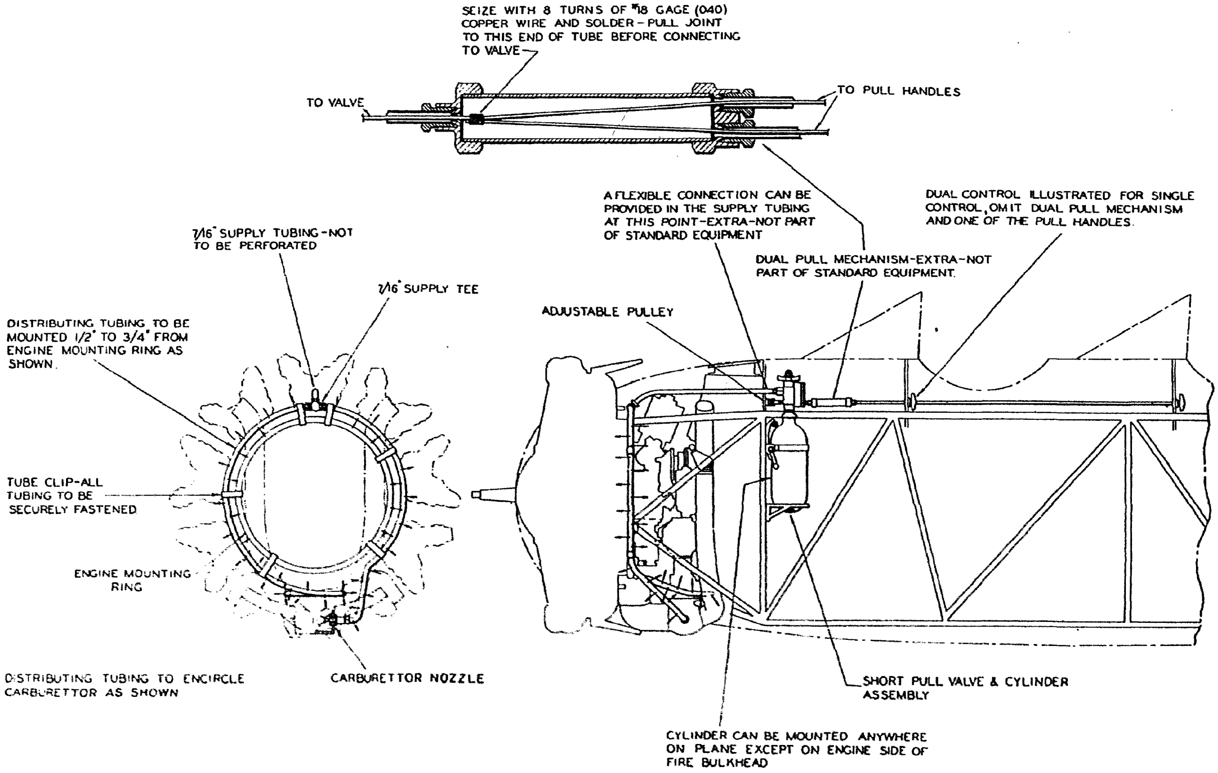
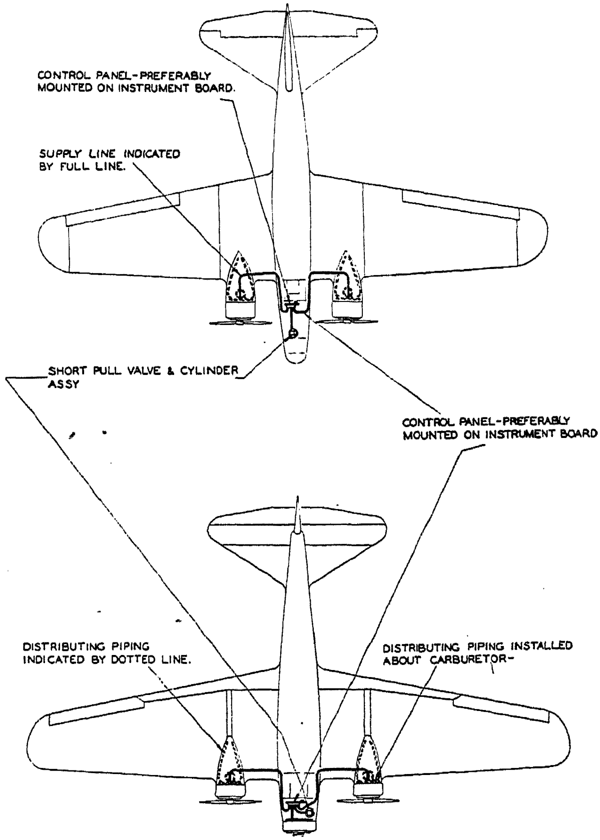

SEIZE WITH 8 TURNS OF #18 GAGE (040) COPPER WIRE AND SOLDER - PULL JOINT TO THIS END OF TUBE BEFORE CONNECTING TO VALVE
TO VALVE
TO PULL HANDLES
A FLEXIBLE CONNECTION CAN BE PROVIDED IN THE SUPPLY TUBING AT THIS POINT-EXTRA-NOT PART OF STANDARD EQUIPMENT
DUAL CONTROL ILLUSTRATED FOR SINGLE CONTROL, OMIT DUAL PULL MECHANISM AND ONE OF THE PULL HANDLES.
DUAL PULL MECHANISM-EXTRA-NOT PART OF STANDARD EQUIPMENT.
ADJUSTABLE PULLEY
7/16" SUPPLY TUBING-NOT TO BE PERFORATED
7/16" SUPPLY TEE
DISTRIBUTING TUBING TO BE MOUNTED 1/2" TO 3/4" FROM ENGINE MOUNTING RING AS SHOWN.
TUBE CLIP-ALL TUBING TO BE SECURELY FASTENED
ENGINE MOUNTING RING
DISTRIBUTING TUBING TO ENCIRCLE CARBURETTOR AS SHOWN
CARBURETTOR NOZZLE
SHORT PULL VALVE & CYLINDER ASSEMBLY
CYLINDER CAN BE MOUNTED ANYWHERE ON PLANE EXCEPT ON ENGINE SIDE OF FIRE BULKHEAD

Fig. 2.—TYPICAL ARRANGEMENT OF "LUX" FIRE EXTINGUISHING EQUIPMENT FOR SINGLE-ENGINE AEROPLANE


CONTROL PANEL-PREFERABLY MOUNTED ON INSTRUMENT BOARD.
SUPPLY LINE INDICATED BY FULL LINE.
SHORT PULL VALVE & CYLINDER ASSY
CONTROL PANEL-PREFERABLY MOUNTED ON INSTRUMENT BOARD
DISTRIBUTING PIPING INDICATED BY DOTTED LINE.
DISTRIBUTING PIPING INSTALLED ABOUT CARBURETOR-

Figs. 3–4.—TYPICAL ARRANGEMENTS FOR TWIN- AND THREE-ENGINE AEROPLANES

To install cylinder, proceed as follows :

(*a*) Weigh the cylinder to determine if its content is fully up to proper charge. If gas charge is less than amount specified by 2 oz. or more, the cylinder must be recharged. See weights stamped on main body bushing.

(*b*) Assemble cutter valve to cylinder. Before doing this, reset the valve. To do this, turn nut *counterclockwise* by hand to stop. Then turn reset nut *clockwise* by hand to stop and then tap reset nut lightly to ensure a gas-tight joint between valve body and reset nut (see Fig. 1). If indicator cap is damaged or lost, it must be replaced. Now, screw valve on fully charged cylinder, using a 10-in. wrench and pulling hard and steady. The thread on the cylinder is *left hand.*

A sight hole is provided in the lower extremity of the valve body to check if the valve is properly seated. If the top of the main body bushing can be seen through this hole, then the valve is not properly seated and should be tightened down further until it is not visible.

(*c*) Fasten the cylinder-mounting bracket securely to the fuselage or bulkhead selected.

(*d*) Place the cylinder in the mounting bracket with the outlets facing in the desired direction and fasten the cylinder securely in place.

(2) Installing Distributing Tubing

When installing the distributing tubing, extreme care must be taken to see that the cross-sectional area of the tubing is not decreased when

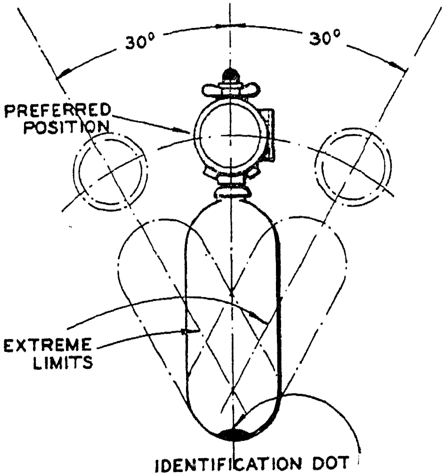


Fig. 5.—Limits for mounting vertical cylinder

shaping or bending the tubing. Also, care should be taken not to scratch or mark the aluminium tubing. The radius of any bend is never to be less than $1\frac{1}{2}$ in. Where a sharper bend is required, fittings must be used. All tubing and fittings must be kept clean and free from metal chips and all other foreign matter, as the presence of any such foreign matter might cause failure of the system.

To install gas tubing, proceed as follows :

(*a*) The first step in the installation of the distributing tubing is to drill a hole in the carburettor air intake just below the butterfly damper to receive the carburettor nozzle. The size of the hole is dependent upon the type of carburettor nozzle used. If the nozzle is of the two-piece type, as shown in Fig. 7, drill a $\frac{25}{32}$-in. diameter hole and install the nozzle as shown. If the carburettor nozzle is of the one-piece type, as shown in Fig. 8, drill a $\frac{37}{64}$-in. diameter hole and tap it for a $\frac{3}{8}$-in. standard tapered pipe thread. Before assembling the nozzle securely into place, coat the threads of the nozzle with a thin coat of anti-seize compound.

(*b*) *On Single-engine Aeroplanes.*—Connect one end of the distributing tubing to the tubing connection of the carburettor nozzle, and shape the tubing around the engine mounting ring, allowing a clearance of from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. between the tubing and the mounting ring as shown in Fig. 2.

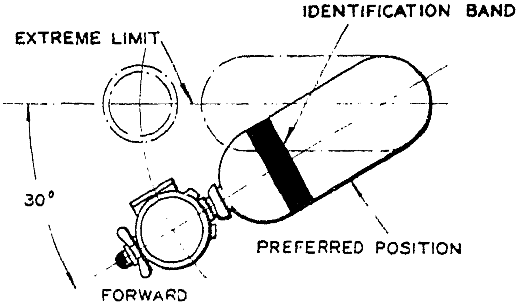


Fig. 6.—Limits for mounting horizontal cylinder

Mark the point where the distributing tubing will enter into the supply tee and then remove the tubing and cut it off at this point. Install the tube plug at the end of the remaining piece of tubing, and then bend this tubing (with the plug end at the carburettor) around the carburettor, and shape it around the engine-mounting ring in the same manner as previously described. Mark the point

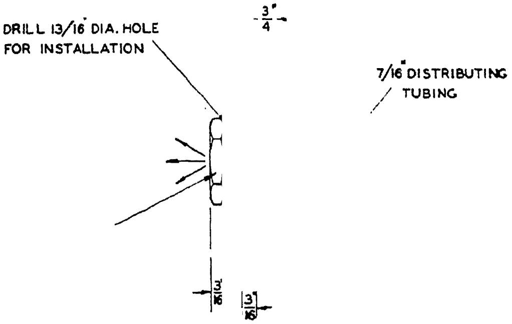

DRILL 13/16" DIA. HOLE FOR INSTALLATION
3/4"
7/16" DISTRIBUTING TUBING
3/16"
3/16"

Fig. 7.—Two-piece type nozzle

where the distributing tubing will enter into the supply tee and cut it off at this point.

Install the tubing, connecting both ends to the supply tee. Fasten the tubing securely to the engine mounting ring, making the fastening clips from the locking strap provided. In fastening the tubing, make sure that the fastening clips do not cover up any of the perforations in the distributing tubing.

(*c*) *On Twin- or Three-engine Aeroplanes.*—The distributing tubing is to be installed in the same manner as described for single-engine aeroplanes, with the exception that when the engine is mounted in a nacelle, additional perforated distributing tubing is to be installed back into the nacelle as shown in Fig. 9. This is accomplished by installing two additional tees (one on each side of the supply tee) and running a line of perforated tubing from each tee back to near the end of the nacelle. At the end of each line, a tube plug is to be installed. Short lengths of perforated distributing tubing are to be used in connecting both additional tees to the main supply tee.

(3) Installing Control Panel

Single Engine Aeroplane

On single-engine aeroplanes there are two types of control handles—that is, instrument-board type and local control type (either one being furnished depending upon equipment used)—for the manual operation of the system.

To install instrument-board type, proceed as follows:

(*a*) Remove the handle and cable from the control panel. Do not kink cable.

(*b*) Drill a $\frac{21}{32}$-in. diameter hole in the instrument board or wherever the panel is to be mounted.

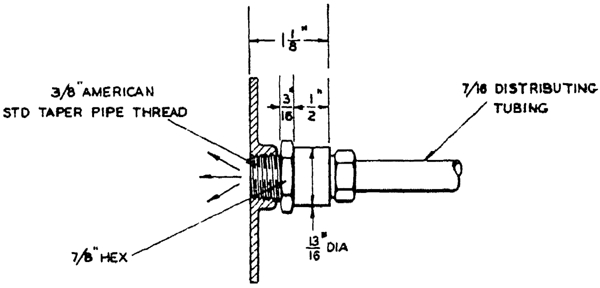


Fig. 8.—One-piece type nozzle

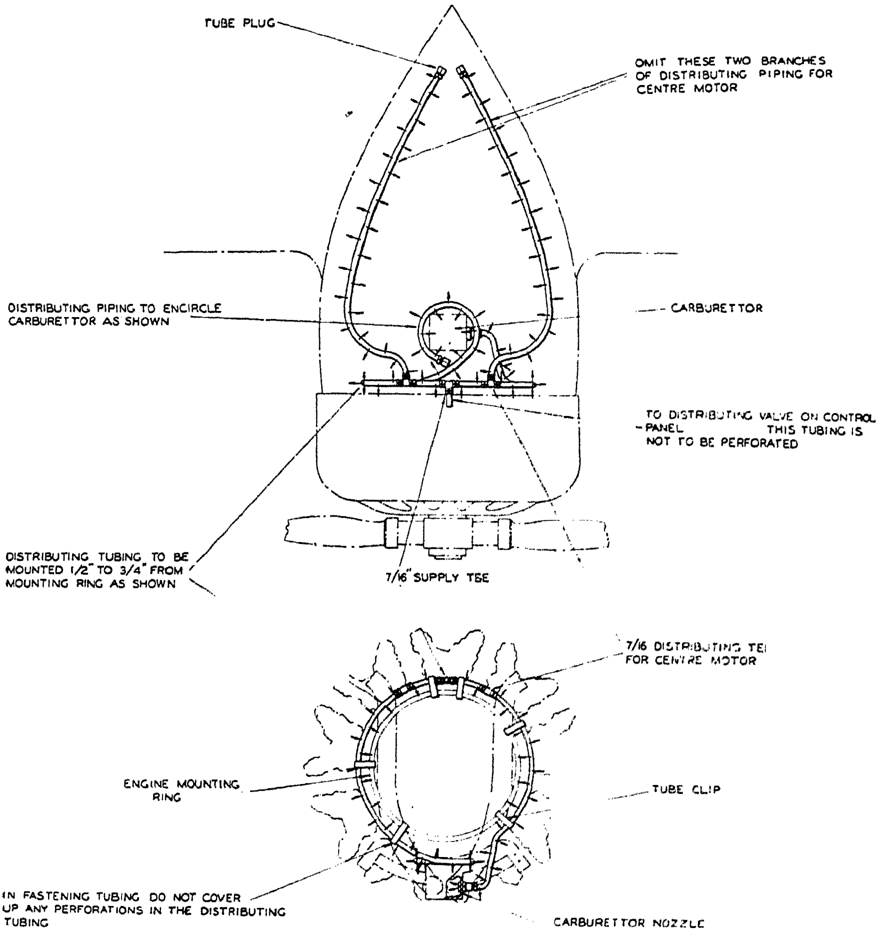

TUBE PLUG
OMIT THESE TWO BRANCHES OF DISTRIBUTING PIPING FOR CENTRE MOTOR
DISTRIBUTING PIPING TO ENCIRCLE CARBURETTOR AS SHOWN
CARBURETTOR
TO DISTRIBUTING VALVE ON CONTROL PANEL THIS TUBING IS NOT TO BE PERFORATED
DISTRIBUTING TUBING TO BE MOUNTED 1/2" TO 3/4" FROM MOUNTING RING AS SHOWN
7/16" SUPPLY TEE
7/16 DISTRIBUTING TEE FOR CENTRE MOTOR
ENGINE MOUNTING RING
TUBE CLIP
IN FASTENING TUBING DO NOT COVER UP ANY PERFORATIONS IN THE DISTRIBUTING TUBING
CARBURETTOR NOZZLE

Fig. 9.—INSTALLATION OF DISTRIBUTING TUBING

Instrument-board Type

The instrument-board type control handle is for installation anywhere in the cockpit or in the pilot's cabin, and should be easily accessible. Preferably, it should be mounted on the instrument board (see Fig. 10).

(*c*) Mount the control panel in front of this hole and fasten in place.

(*d*) Mount the cable socket in place as shown in Fig. 10.

Local Control Handle

This type of control handle is to be used only when the cylinder is installed in the pilot's cockpit, and within easy and direct reach of the pilot's hand. Also, it is very important that it be readily visible to the pilot (see Fig. 11).

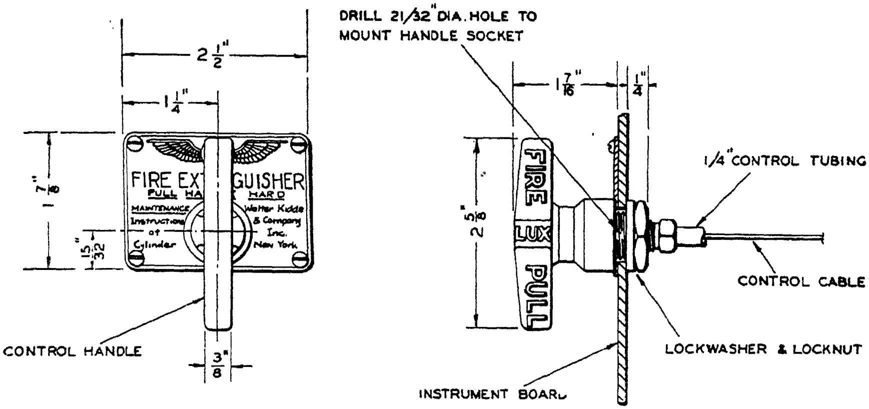


Fig. 10.—INSTALLATION OF INSTRUMENT-BOARD TYPE CONTROL PANEL

To install local control handle, proceed as follows :

(*a*) Loosen the screw of the cover of the manual release lever housing and swing cover away. Loosen clamping screw on manual release lever, and remove the short length of cable with the clevis pin attached.

(*b*) Remove the handle and cable from the handle socket. Do not kink the cable.

(*c*) Screw the handle socket firmly into the manual release lever chamber.

Twin- or Three-engine Aeroplanes

For twin- or three-engine aeroplanes, there is only the instrument-board type of control panel available for the manual operation of the system. This panel is shown in Fig. 12.

To install panel, proceed as follows :

(*a*) Remove the handle and cable from the control panel. Do not kink cable.

(*b*) Scribe on instrument panel (or on whatever it is decided to mount the control panel) the outline as indicated in Fig. 12 on page 13. Cut out this section.

(*c*) Mount the control panel in front of this cut-out section and fasten the control panel in place.

(4) Installing Supply Tubing

When installing the supply tubing, extreme care must be taken that the cross-sectional area of the tubing is not decreased when shaping or bending the tubing. Also, care should be taken not to scratch or mark the aluminium tubing. The radius of any bend is never to be less than 1-1½ in. Where a sharper bend is required, fittings must be used. All

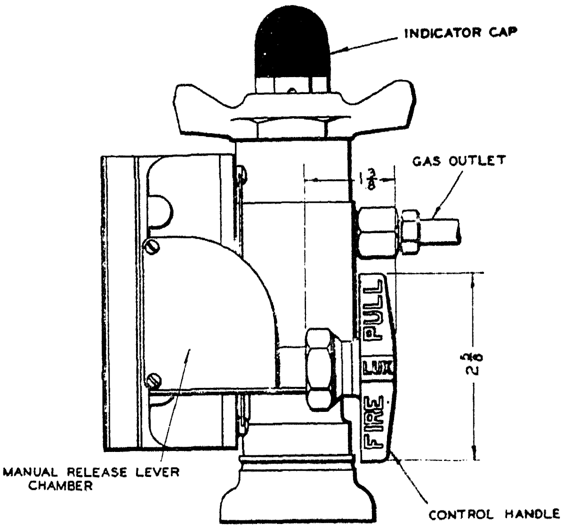


Fig. 11.—Local control handle

tubing and fittings must be kept clean and free from metal chips and all other foreign matter, as the presence of any such foreign matter may cause failure of the system.

To install supply tubing, proceed as follows :

Single-engine Aeroplane

(*a*) Run the supply tubing from the supply tee at the distributing piping to the gas outlet at the cutter valve.

(*b*) Fasten the supply tubing securely, using the locking strap provided. It is essential that the supply tubing be rigidly fastened.

Twin- or Three-engine Aeroplanes

(*a*) Run the supply tubing from the gas outlet of the cutter valve to the inlet of the distributing cock mounted on the back of the control panel.

(*b*) Run the supply tubing from the supply tee at the distributing piping of each engine to the proper outlet of the distributing cock. Carefully check each connection, as it is essential that they be properly made in order to ensure that the " Lux " gas is conveyed to the engine desired at time of fire.

(*c*) Fasten all supply tubing securely, using the locking strap provided. It is essential that all supply tubing be rigidly fastened.

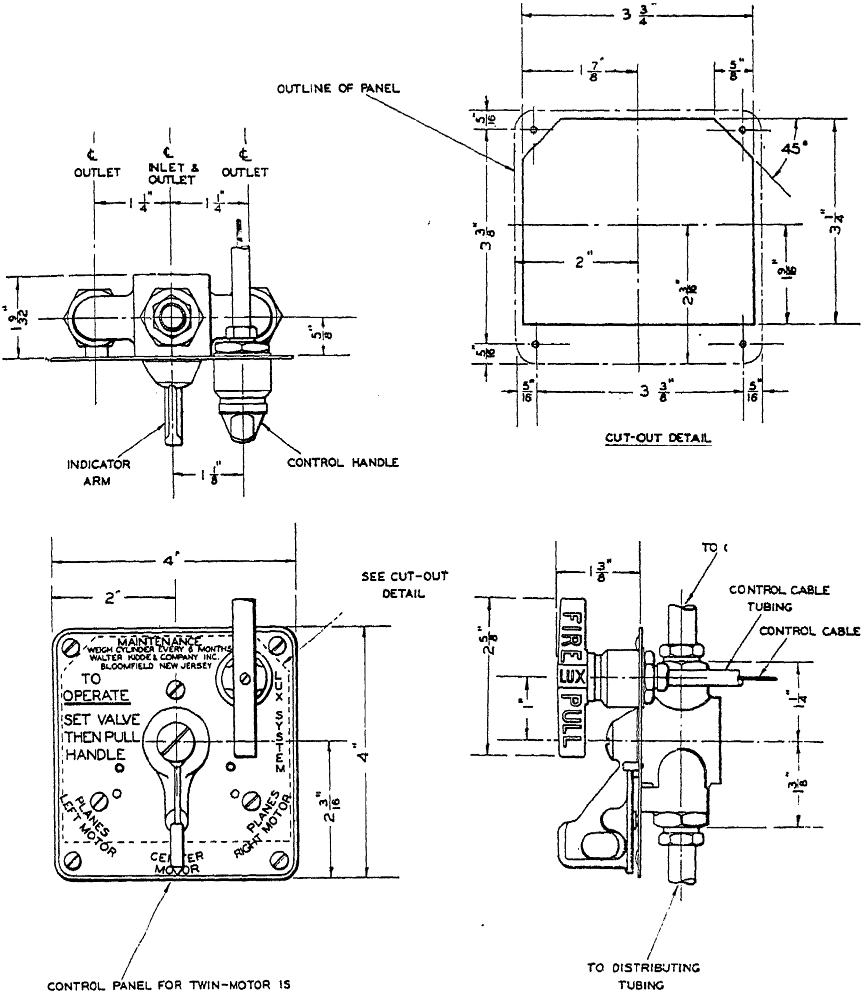
(5) Installing Control Tubing, Corner Pulleys, and Cable

The control-cable line should be kept as short and as direct as possible, in order to minimise the pull required for operation.

When installing this tubing, care should be taken in order not to crush the tubing.

Important Note

Under no circumstances are bends or offsets to be made in the control-cable tubing. Use " Lux " adjustable corner pulleys (see Fig. 13) at all bends. *This is very important.*



CONTROL PANEL FOR TWIN-MOTOR IS INDENTICAL EXCEPT THAT "CENTRE MOTOR" IS OMITTED.

Fig. 12.—INSTRUMENT-BOARD TYPE CONTROL PANEL FOR TWIN- OR THREE-ENGINE AEROPLANES

With Instrument-board Type Control Panel

(*a*) Flare end of control-cable tubing and connect to pull-handle socket.

(*b*) Apply a thin coating of graphite to cable, and then feed cable through the front of the control-handle socket and through the control-cable tubing. If tubing is to be installed in two pieces, the cable should be threaded through the first length, a union should be installed on the

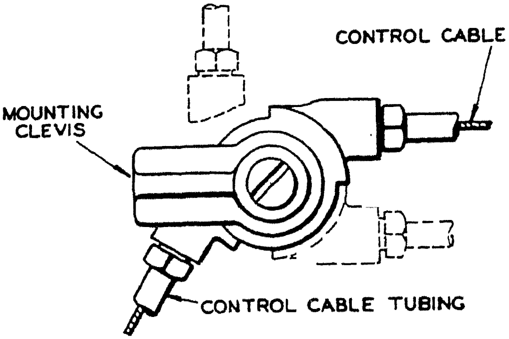


Fig. 13.—"Lux" ADJUSTABLE CORNER PULLEY

end of this length, and the cable then threaded through the second length of tubing. Make up the union connecting the two pieces of control tubing. Pull free end of cable taut so that control handle rests correctly in the handle socket.

(*c*) Run cable in cable tubing to the manual release lever housing at the cutter valve, keeping the run of the tubing as straight as possible in order to minimise pull required for operation. At all bends, "Lux" adjustable pulleys (these pulleys are so constructed that they may be installed at any angle—see Fig. 13) must be used. Support the tubing rigidly throughout its entire length.

(*d*) If it is decided totally to enclose the control cable, or if a corner pulley is to be mounted on the control-cable outlet of the valve, as shown in Fig. 14 (below), loosen the screw of the cover of the manual release lever housing and swing cover away. Loosen clamping screw on manual release lever and remove the short length of cable with the clevis pin attached. Mount corner pulley on valve, if required. Thread control cable through the cable outlet or through the corner pulley, and make necessary cable tubing connections. Pull control cable taut. Place cable in groove of cable clamp on manual release lever and mark location where it is to be knotted. Remove cable, knot and tin it, and then cut off excess. Clip cable into clamping groove and tighten clamping screw securely. Close cover and tighten screw.

If it is decided not totally to enclose the control cable, connect the control cable to clevis pin on the end of cable furnished with valve.

With Local-type Control Handle

No control tubing is necessary to be run with this type of control handle, as the handle socket is mounted directly on the lever chamber, as shown in Fig. 11. To connect control handle to manual release lever, proceed as follows:

(*a*) Apply a thin coating of graphite to the cable attached to the control handle and feed the cable through the front of the control cable socket into the release lever chamber. Pull control cable taut so as to ensure proper seating of control handle in socket.

(*b*) Place end of cable in groove of cable clamp and tighten clamping screw securely. Close cover and tighten screw.

Note.—The manual release lever can be moved in an angle of approximately 15° with safety, after which an additional angular movement of 15° will cause the valve to operate.

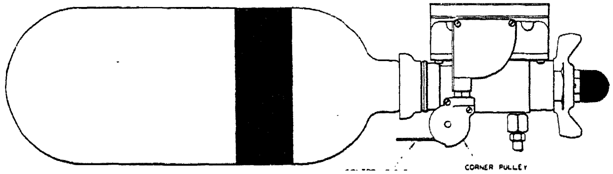


Fig. 14.—CORNER PULLEY MOUNTED ON CONTROL-CABLE OUTLET

(6) After Installation is Completed

Review the entire installation and make certain that all the equipment has been installed in strict accordance with these instructions.

MAINTENANCE

The "Lux" fire-extinguishing system requires no more than ordinary care to ensure its proper operation. Frequent inspections should be made in order to determine the exact condition of the apparatus, as this system is for occasional emergency use and, therefore, must be constantly kept in operating condition.

It is recommended that the system be tested once every four months. The test should be conducted at a temperature of about 70° F.

To test the system, proceed as follows :

(1) If at all possible, the test should be made with the aeroplane in flying position, as this is nearer the actual position of the aeroplane when the system is operated in actual practice.

(2) If the system to be tested is installed in a twin-engine aeroplane, set the distributing cock to either of the two engines in order to provide an outlet for the gas. On three-engine aeroplanes, the distributing cock is normally set to the centre engine.

(3) Hook a spring-balance scale over the pull handle, and pull with a slow uniform pull until the system is operated. Observe the force that was required to operate the system. This force should not exceed 50 lb.

(4) Upon operation of the system, the gas should discharge about the motor. On twin- or three-engine aeroplanes, the gas should discharge about the engine indicated on the control panel by the distributing cock handle.

(5) Remove the discharged cylinder, and have it recharged and replaced immediately. To remove cylinder, proceed as follows :

(*a*) *When control cable is totally enclosed,* loosen screw of the manual release lever chamber and swing cover away. Loosen clamping screw and cable clamp on the manual release lever and lift out cable. Now, disconnect cable tubing from manual release lever housing.

When control cable is connected by means of clevis pin, remove the control cable from the clevis pin.

When control handle is mounted directly on cutter valve, it is unnecessary to remove the control handle from the cutter valve.

(*b*) Disconnect gas tubing from gas outlet on cutter valve.

(*c*) Loosen cylinder strap and remove cylinder from plane.

(*d*) Using a 10-in. wrench, unscrew the cutter valve from the main body bushing (left-hand thread). *Do not* remove main body bushing from cylinder.

(*e*) Have cylinder recharged to its full capacity.

(6) Before reassembling cutter valve to fully charged cylinder, examine the cutting edge of the cutter. If it has been damaged in any way, it *must be replaced.* Do not attempt to repair it. Reset the valve. To do this, turn wing nut *counterclockwise* by hand to stop. Then turn wing nut *clockwise* by hand to stop, and then tap wing nut lightly to ensure gas-tight joint between valve body and reset nut. If indicator cap is damaged or lost, it must be replaced with a new one.

(7) Assemble cutter valve to fully charged cylinder, using a 10-in. wrench and pulling hard and steady. The thread on the cylinder valve is *left-hand.* A sight hole is provided in the lower extremity of the valve body to check if the valve is properly seated. If the top of the main body bushing can be seen through this hole, then the valve is not properly seated, and should be tightened down farther until it is not visible.

(8) Reinstall fully charged cylinder.

Caution.—When removing or reinstalling a charged cylinder, the manual release lever can be moved in an angle of approximately 15° with safety, after which additional angular movement of 15° will cause the valve to operate.

If the system is not discharged periodically, every four months, as described above, remove and weigh the cylinder at least once every six months. See items 5 (*a*) and 5 (*d*) inclusive, for instructions on removing the " Lux " cylinder. If, when weighing the cylinder, it is found that the gas charge is less than the full capacity of the cylinder by 2 oz. or more, the cylinder must be recharged to its full capacity. Record the weight and other data on the record card, stored in slot under nameplate on cutter valve.

Caution.—When removing or reinstalling a charged cylinder, the manual release lever can be moved in an angle of approximately 15° with safety, after which additional angular movement of 15° will cause the valve to operate.

OPERATION

The following notes relate to the method of operating the " Lux " fire extinguishing equipment.

For Single-engine Aeroplane

(*a*) Pull handle on " Lux " control panel marked " Fire—Pull."

For Twin- or Multi-engine Aeroplane

(*a*) Set distributing cock on "Lux" control panel to motor afire.
(*b*) Pull handle marked "Fire—Pull."

Before Flight—Important

Inspect indicator cap on cutter valve to make sure that it is unbroken and shows clear. If indicator cap shows red, or if indicator cap is broken, have cylinder removed, recharged, and replaced immediately.

After System has been Operated

(1) Remove the empty cylinder and have it recharged as soon as possible. (See instructions given under "Maintenance.")

(2) On multi-engine planes, reset the distributing cock to its normal set position.

(3) Reset the control handle and cable. Work the cable back and forth a few times to make certain that it does not bind.

(4) Inspect the perforations in the "Lux" distributing tubing to see if any are clogged up. Also, remove the tube plug at ends of "Lux" tubing and remove any dirt or foreign matter. Replace cap.

(5) Inspect indicator cap on cutter valve. If damaged, it *must be replaced* with a new one.

(6) Reinstall the recharged "Lux" cylinder. (See instructions given under "Maintenance.")

Acknowledgment

We are indebted to Messrs. Walter Kidde & Co., Ltd., for the above information.

"ESSEX" FIRE-EXTINGUISHING EQUIPMENT

METHYL bromide is used in the "Essex" equipment for the fire protection of aeroplanes, and is extensively employed by the Royal Air Force, on account of its very low weight-efficiency ratio.

Briefly, methyl bromide is a volatile liquid, boiling at 4·5° C., giving off a gas three and a quarter times heavier than air, and is strongly fire deterrent. At 20° C. it would have a vapour pressure of 12 lb. per square inch, but this is artificially increased in "Essex" equipment to 50 lb. per square inch (in the case of the No. 4 special aeroplane type to 150 lb. per square inch in order to produce a discharge in the shortest possible time). The low pressures involved enable very light equipment to be used. Methyl bromide is ideally adapted for fire-extinguishing purposes, and its action is fourfold :

(*a*) Fire is usually the oxidation of carbon in a substance. The heavy methyl-bromide gas tends to displace the air in the vicinity of the fire and therefore to prevent the access of oxygen, without which the fire cannot continue.

(*b*) The low boiling-point of the medium (which has, in fact, been used as a refrigerant), coupled with a relatively high latent heat and almost instantaneous evaporation, causes a rapid absorption of heat locally, and tends literally to "freeze" the fire out.

(*c*) The strong jet from hand-operated extinguishers tends to knock the fire out, as is the case with water and other liquids applied under pressure.

(*d*) Methyl bromide has an effect of preventing molecular interaction, which may be termed "inhibition." Research has shown that the mere dilution of atmosphere cannot account fully for the fire-fighting effect of various media. Whereas 19% CO_2 will extinguish most petrol fires, only 15% CTC is needed for the same effect, while in the case of methyl bromide only 3% is required.

Hand Extinguisher

"Essex" hand extinguishers consist simply of copper bottles filled with methyl bromide under 50 lb. per square inch pressure and provided with striker mechanisms to pierce the 0·015 in. copper sealing discs, thus liberating the liquid through the jets provided. The extinguishers are

TECHNICAL DATA

Property	*Methyl bromide*	*Carbon tetrachloride*	*Carbon dioxide*
Structure	CH_3Br	CCl_4	CO_2
Molecular weight (O = 16·0)	94·949	153·845	44·005
Specific gravity (water = 1·0)	1·732	1·6326	0·77
Vapour density (air = 1·0) at N.T.P.	3·27	5·31	1·52
Boiling-point at 757·6 mm.	4·5° C.	76·7° C.	– 78° C.
Melting-point	– 93°C.	– 30° C.	—
Specific heat of liquid at 0° C. cals/gram	0·123	0·1854	0·201
Latent heat of vaporisation cal/gram at B.P.	62·06	46·0	90
Vapour pressure at 20° C. in absolute lb. per square inch	27·6	1·75	810
Gas generation, cubic feet per lb. at N.T.P.	3·7	2·3	8·0
Inhibitory factor % for petrol	3·0	15·0	19·0
Diffusion coefficient grms./cm.^{2}/sec./air	0·097	0·076	0·142
Percentage recommended for concentration method of extinction	5	25	50
Relative toxicity at this strength	14	26	10
Normal pressure in cylinders lb. per square inch at 15° C.	50	80	810

securely held until required in strong brackets, from which they are capable of instantaneous removal by pulling. Operation thereafter is by striking the plunger knob upon the ground, cockpit floor, or the knee, keeping the plunger knob at the lower end.

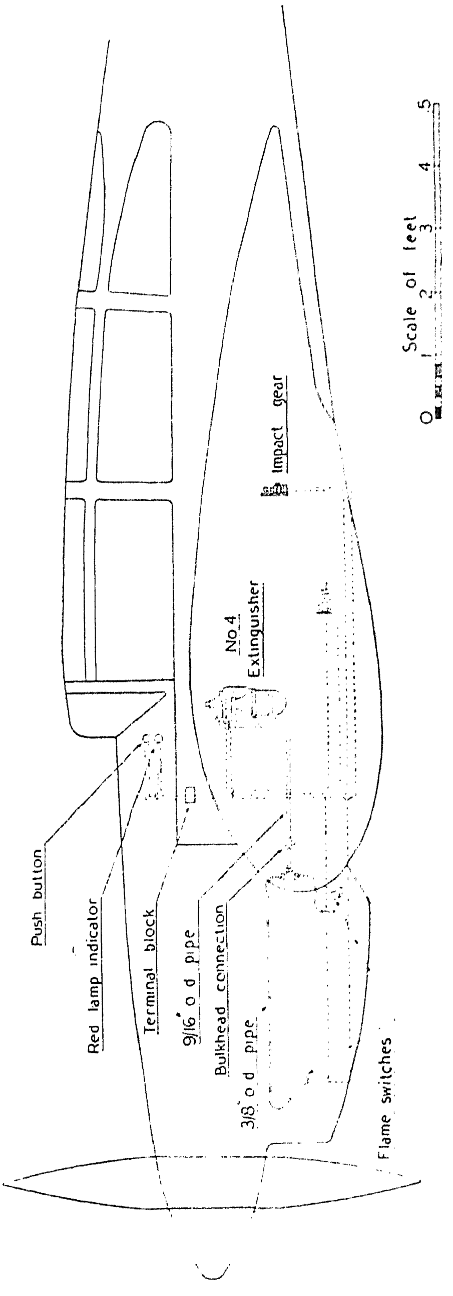
It is important that the extinguisher in its bracket be fastened with the plunger knob at the bottom, and with the lettered instructions on its side the right way up. Vertical (or within 45° of the vertical) is essential. This automatically ensures that it is used the correct way when directed at the fire.

The contents emerge from the jet in the form of a liquid, rapidly boiling, and should travel in liquid form for a distance of at least 15 ft. when the extinguisher is held vertically. This distance will be more for the larger sizes, since longer jets are incorporated. When refills are required, it is only necessary to unscrew the plunger mechanism and then to screw on in place a fresh container, making the joint gas tight with the washer provided.

The Featherspray

The Featherspray device involves the combination of a standard " Essex " extinguisher with a pipe line, thereby affording a remote control for discharge at some inaccessible point, retaining at the same time the immediate removability of the extinguisher for use as a hand-directed type.

In its simplest form, the extinguisher is held by clips in a bracket, having a cam-operating lever handle at the lower end, which, when forced upwards, pierces the inner seal and liberates the contents over the remote carburettor.



The first step towards a fully automatic fire-extinguishing device is the provision of an electrically operative method to take the place of the hand-operated cam. The electric circuit is completed by a specially designed "flame contact switch" placed over the carburettor or other place where flames may be expected. A piece of nitrated cotton in tension holds the contacts apart until the presence of a flame breaks the cotton, completing the circuit.

Owing to the forces brought into play with the electrical type, the bracket is made of steel, but in the simple Featherspray device a lattice form of duralumin is invariably used for aeroplane purposes.

The detail of the pipe line will naturally vary as between different aeroplanes, but not more than two discharges should be employed with a No. 2 set, nor more than three with a No. 3 set. Carburettors can be protected by sprayheads fastened above them and pointing downwards and aft. Other discharges, as for example in nacelles below carburettors, should be simply open-ended $\frac{3}{16}$-in. o.d. pipe without sprayheads.

Aircraft Automatic Set

The aircraft automatic set comprises an extinguisher

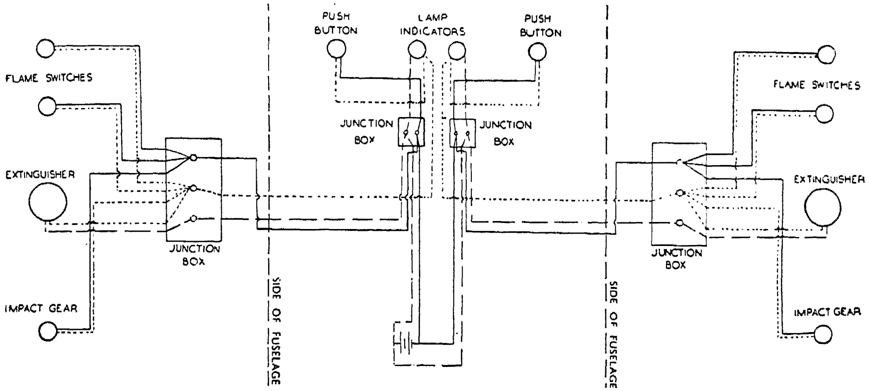


Fig. 2.—WIRING DIAGRAM FOR "ESSEX" AUTOMATIC FIRE-EXTINGUISHER FOR TWIN-ENGINE AEROPLANE

container of capacity double that of the No. 3 size, and while retaining the Featherspray principle of combining a hand extinguisher with remote control through a pipe line, it includes automatic crash operation, with the object of preventing fire after the tanks have burst.

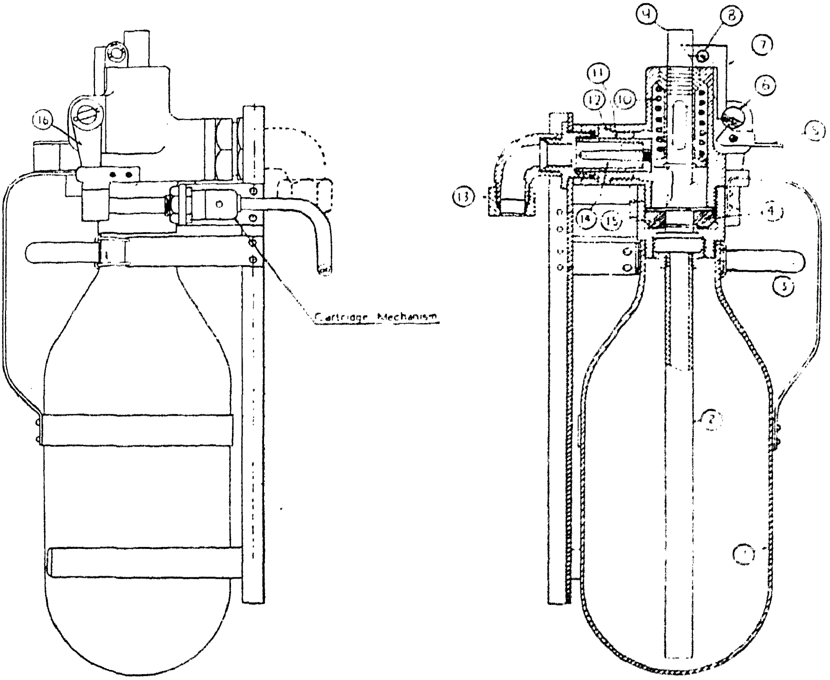
Two or more Engines

Aeroplanes fitted with two or more engines should have one complete extinguisher and set of equipment to each engine. In such a case the extinguisher would be fixed in the engine nacelle and behind the fireproof bulkhead provided, but naturally out of hand reach of the pilot, who would depend upon the automatic operation and the press buttons with lamp indicators in the cockpit. For multi-engined aeroplanes, therefore, it is not necessary to employ a removably fixed extinguisher, and the extinguisher should be rigidly fastened to its bracket, both the thumb trigger and the adjustable flow valve being removed.

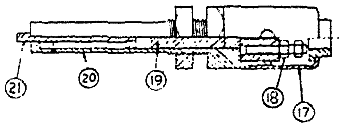
Method of Installation

The extinguisher is intended for use with a single-engine aeroplane of which a typical layout appears in Fig. 1. In such a case, the extinguisher is fitted in the cockpit, with the $\frac{9}{16}$-in. o.d. pipe led through the fireproof bulkhead, terminating in probably two discharges in the nacelle. The extinguisher is available for instant removal for use as a hand-directed appliance in any accessible part of the aeroplane. In this case no other extinguisher need be carried, except where the presence of smoking compartments necessitates further extinguishers in accordance with A.N.D. regulations.

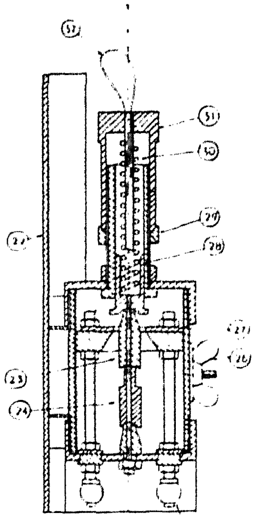
Careful consideration of the slipstream and eddies is necessary before determining the best position for, and the number of, the pipe discharges,



No 4 AC
EXTINGUISHER
IN
BRACKET



CARTRIDGE MECHANISM
DETAIL



CRASH
IMPACT GEAR
IN BRACKET

Fig. 3.—The "Essex" automatic fire-extinguishing set for aeroplanes

Generally, two will be sufficient to each engine. These will be open-ended $\frac{3}{8}$-in. o.d. pipe branching from the special reducing Tee joint provided. A $\frac{9}{16}$-in. o.d. bulkhead union is also provided. One discharge should be above and forward of the carburettor, while another should be placed to discharge over the oil cooler and/or the lowest portion of the nacelle into which fuel from the carburettor or broken pipe might collect.

In the case of two branching pipes of equal diameter but unequal length, the rate of flow from their respective extremities varies inversely as the square roots of the lengths involved. If equal rates of flow are desired, as will usually be the case, the end of the shorter pipe should be proportionately closed.

An electrical flame contact switch should be fixed, by means of the lug incorporated upon it, immediately above the carburettor, and according to aeroplane type, another fixed above the oil cooler. This switch involves a contact-maker in a cylindrical body held away from spring contacts by means of a nitrated cotton link, and thus acts when exposed to a flame. Heat operation may be substituted by employing a low-temperature link for the cotton. The former is to be preferred, owing to its speed of action, which is essential for dealing with a fire while in flight.

Fig. 2 is a wiring diagram for a twin-engine aeroplane, showing the position of the junction boxes (or terminal blocks). Those with three terminals, though necessary in the system, are intended primarily to facilitate easy wing removal and reassembly. Though only one impact gear is strictly necessary for crash operation, it is essential to fit one to each engine, in order to preserve the independence of the protection system in each nacelle, and prevent the possibility of all engines cutting out when a fire occurs in only one.

The Extinguisher (Fig. 3)

Five pounds methyl bromide under 150 lb. per square inch nitrogen pressure are sealed in the solid-drawn copper container (1) by means of a 0·005-in. thick copper seal (15) secured by the brass screwed plug valve (4). The hollow piercer (9) is held in position against a compressed spring (10) by the detent (7) capable of rotation about the pin (8). The detent is prevented from rotating by the cam (6), which itself may be rotated, so as to free the detent, by either the thumb trigger (5) or the lever (16).

When the extinguisher is held in the bracket by the clips and quick removal arm (3), the thumb trigger (5) cannot be operated owing to the presence of a preventer distance piece which abuts upon the extinguisher handle. The lever (16) is normally held in position by a spring guard-but can be operated by the forcing outwards of the piston rod (21) in, corporated in the cartridge mechanism. This would occur when the external electrical circuit had been completed, resulting in a very light explosion of the cartridge (19). Electrical wires are connected to the terminals (18) protected by a metal cap (17).

The hollow sleeve valve (11) is free to move horizontally in the combined valve seat and cylinder (12). The valve is in the open position while the extinguisher is in the bracket, owing to the sleeve abutting upon a shoulder in the union gland incorporated in the bracket. This allows an area discharge larger than the dip tube (2) and capable of emptying the contents in less than three seconds. When the extinguisher is removed from the bracket for hand-directed use, pressure on the inner face of the valve closes it, and allows of a discharge through the central jet (14) giving a 10-ft. to 15-ft. throw for one minute.

The Impact Gear

The toggle links (23) and (24) stand upon an anvil under the pressure of the contact-maker (28) and compression of spring (30), which is capable of adjustment by the micrometer head (31) and locking ring (29).

The device is held in a bracket (22) by a clamp and wing nut (26). The bracket requires to be fastened rigidly to the aeroplane. When a blow at right angles to the axis of the toggle links is sustained, they will break, allowing the contact-maker (28) to connect the contact plates (27) supplied by the terminals (25). The links may be instantly reset by pulling the gut string (32).

A scale is provided upon the micrometer head to enable the spring compression to be set to correspond to any degree of impact between " 3 g." and " 10 g.," and as the thread pitch corresponds to " 0·5 g.," fine adjustments are possible. Positive tests of the impact adjustment may be made, if desired, by removing the device from its bracket and hanging specially calculated weights (each corresponding to " 1 g.") from the centre of the links, through the hole provided in the barrel casing, when held in a horizontal position. A set of test weights is supplied with each impact gear.

We are indebted to the National Fire Protection Co., Ltd., for the above details.

THE INSTALLATION AND MAINTENANCE OF LEAD-ACID BATTERIES IN AEROPLANES

THERE are two distinct designs of lead-acid batteries available for use in aeroplanes, the non-spillable battery and the semi-non-spillable battery.

The choice of design depends upon the aeroplane in which the batteries are to operate. Aeroplanes which come within the aerobatic category must be fitted with batteries of the fully non-spillable type, whilst, on the other hand, aeroplanes which are not in the aerobatic category may be fitted with batteries of the semi-non-spillable type. Some designers, however, show a preference for the fully non-spillable type of battery whatever the class of aeroplane, but in such cases it should be borne in mind that capacity for capacity the fully non-spillable battery is usually more bulky than the semi-non-spillable battery.

A fully non-spillable battery is one which can be inverted or placed in any other position without the risk of any acid electrolyte escaping through the hole which must be provided in each cell to allow for the liberation of gases which are generated inside the cell.

A semi-non-spillable battery is one which, although not capable of being inverted with safety, will prevent the escape of acid electrolyte owing to splash when in the normal upright position, and also when inclined at the angles to the vertical met with during normal flight conditions.

Size

The choice of the correct size of battery to be fitted requires very careful consideration of several variable factors, as follows :

(1) The low- and high-rate current discharges which will normally be required for such duties as instrument operation and lighting, navigation and landing lights, fuel pumps, radio, engine-starting, and the operation of flaps and undercarriage, etc.

(2) The size and number of generators fitted to the aeroplanes.

(3) Weight and space available.

(4) Life expected from the battery.

Consultation with the actual battery makers will usually result in a satisfactory compromise, but the following points are included as being of general interest.

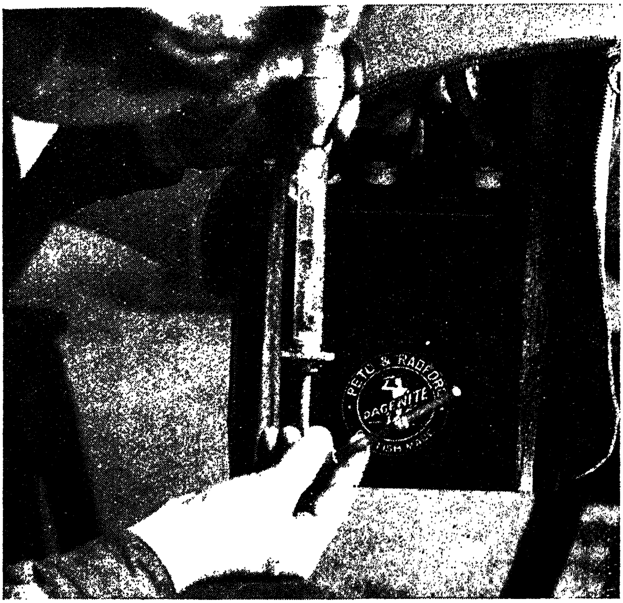


Fig. 1.—CHECKING A 12-VOLT BATTERY WITH A HYDROMETER

In the case of large multi-engine aeroplanes, the battery size canbe reduced by making provision for external engine-starting from cold by means of high-capacity batteries which can be wheeled about the aerodrome on mobile starting trolleys.

One method of arriving at the size of the battery is to assume that the generators are out of action for a prescribed period, which may be calculated from the time taken to reach a given aerodrome from the point of failure of the generators, and then to compute the various currents required from the battery, for emergency and essential electrical services.

All aeroplane batteries are of light-weight construction, including the use of thin plates, but here, again, still further reduction in battery weights can be obtained at the expense of life in special cases, and a compromise may again be necessary after consultation with the battery makers.

Installation

The batteries should be located in an accessible position in order to facilitate topping-up, the taking of specific-gravity readings, and periodic removal from the aeroplane for external charging. These processes are fully described later under the heading of "Maintenance."

In the case of large aeroplanes, which may require several batteries, it is advisable to mount them on a movable platform supported on wheels or rollers. This arrangement allows the batteries to be moved easily into a more accessible place for the purpose of installation, maintenance, and replacement.

During charge, and particularly when overcharged, lead-acid batteries give off a gas which is a mixture of oxygen and hydrogen. Although this small quantity of gas is not harmful it carries with it minute traces of the electrolyte, and for this reason it may in a confined space cause irritation to the throat, and therefore if the batteries are located in the pilot's cockpit it is advisable to provide an enclosed battery compartment which can be vented away from the cockpit either to the outside of the aeroplane or else to some convenient place inside. If the batteries are installed in an enclosed compartment it is most important to provide adequate ventilation, so as to prevent an undesirable accumulation of the gas.

Maintenance

The normal useful life which a battery may be expected to give depends mainly on the following two factors :

(1) An adequate and correct *first* charge.

(2) Careful and periodic maintenance.

Most batteries will be received fully charged and complete with acid, and in such cases they will require only a short freshening charge before being put into service.

Fig. 2.—SEMI-UNSPILLABLE TYPE AEROPLANE ACCUMULATOR

Showing method of checking specific gravity. The electrolyte level is adjusted by the addition of distilled water through the special vent with white cap. The correct level will be indicated by the white top of the indicator float, which rises and closes the orifice. The device used for adding water must not be allowed to interfere with the free rising of the level indicator.

Freshening Charge.—Check the level of the electrolyte in each cell and if necessary adjust to the correct level, as stated in the battery instructions, by the addition of *pure distilled water* (*see* later paragraph headed "Acid Level").

Then charge at the normal rate stated in the instructions until voltage and specific-gravity readings remain constant for four hours (*see* later paragraph headed " Acid "). In cases of emergency this freshening charge may be dispensed with if it is reasonably certain that the battery has recently been fully charged.

First Charge.—If the battery is received unfilled with acid it must be given a first charge, and this must be carefully carried out in accordance with the makers' instructions, which should accompany each battery.

First-charge instructions vary according to the make, design, and capacity of the battery, and therefore it is impossible to give here a detailed description to cover every type, but the following general information will augment the individual makers' instructions :

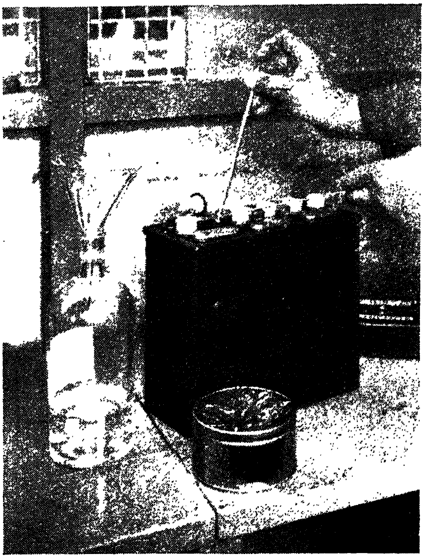


Fig. 3.—THE UNSPILLABLE TYPE AEROPLANE ACCUMULATOR

Showing method of checking acid level. The special vent is removed and the celluloid tube inserted, marked end first, and placed vertically on top of the plates. The fore-finger tip is placed over the top of the tube to form an air-lock and the tube withdrawn. The correct acid level is indicated between the two red bands on the tube.

Acid

The electrolyte consists of pure accumulator sulphuric acid diluted with distilled water to the required stated specific gravity. Acid of the required specific gravity can usually be purchased, but should it ever be necessary to dilute acid with distilled water in order to reduce the specific gravity, the acid should always be added to the water. On no account add the water to the acid except for the purpose of slight adjustment of the specific gravity after testing with the hydrometer.

Heat is produced by the chemical action between the acid and the water, therefore great care should be taken to comply with these instructions.

The mixing vessels must be clean and of glass or earthenware, and the mixture should be stirred with a glass or ebonite rod. Metal vessels or stirring rods must not be used, as all common metals except lead are affected by sulphuric acid, which will absorb impurities and cause damage to the battery.

After mixing, the solution should be allowed to cool to the temperature of the surrounding atmosphere, approximately 60° F. in temperate climates, and 90° F. in tropical climates.

The specific gravity of the acid is best ascertained by means of a hydrometer of the syringe type, as illustrated in Fig. 1. When taking specific-gravity readings on an actual battery, always take care to return the extracted acid to the cell from which it was taken.

Temperature

Corrections to specific-gravity readings observed at temperatures other than the normal of 60° F. must be made as follows :

For every 5° F. *below* 60° F., *subtract* two points from the observed reading, and for every 5° *above* 60° F. *add* two points to the observed reading ; e.g. an observed reading of 1·270 at 70° F. is equivalent to a specific gravity of 1·274 at the normal temperature of 60° F.

Acid Level

British fully non-spillable batteries are fitted with patented vent devices (P. & R. Nos. 464,282, and 464,401), which allow the battery to be inverted or turned into any other position without the acid being allowed to escape. The whole effect of the special design features which make the battery unspillable in any position will be lost if the acid is allowed appreciably to exceed the correct level.

It is therefore most important to check the level at least once a fortnight, and adjust it if necessary. Careful adjustment must be carried out after the first charge and each subsequent recharge.

The correct acid level is stated by the maker on each battery, and whilst this level should not be exceeded it is also a most important feature of correct maintenance to see that the acid level is not allowed to fall below the tops of the plates. The acid level falls mainly owing to evaporation of the water constituent of the electrolyte, and therefore this loss should be made good by the periodic addition of distilled water only, not acid. The addition of distilled water is known as *topping-up*.

The acid level is best ascertained by using a tube of glass or other transparent material. Remove the vent plugs from the cells and insert the tube through the vent hole so that one end rests on top of the separators ; then place the thumb over the other end and withdraw, still keeping the thumb in position. The height of the column of acid held in the tube will indicate the height of acid over the tops of the *separators*, one of each of these being located between each pair of adjacent plates.

On removing the thumb the acid will run out of the tube, but it is advisable to blow through the tube after each test in order to clear away any drops of acid which may remain behind.

After use the tube should be thoroughly washed in clean water. If acid is spilt on the aeroplane or clothing, neutralise at once with ordinary household ammonia.

All Peto & Radford Dagenite non-spillable batteries are supplied complete with a special non-breakable measuring tube, which is marked at one end with two red bands to indicate the safe minimum and maximum acid levels. The tube is accommodated in two clips fixed to the battery hold-down bar.

Once correct adjustment to acid specific gravity has been made at the end of the *first* charge, the acid level should subsequently be maintained by the addition of distilled water only.

In the case of semi-non-spillable batteries this attention to correct acid level is also important, in order to preclude any syphoning action and also to prevent the escape of acid owing to splash. A patented filling device in each cell is incorporated in the Peto & Radford range of semi-non-spillable batteries. The arrangement comprises the combination of a float and a valve which shuts off any further supply of topping-up water to the cell once the predetermined safe acid level is reached.

Specific Gravity

The specific gravity or strength of the acid is a very useful guide to the condition of the battery, because at any given time the specific gravity of the acid is directly proportional to the state of charge or discharge of the battery.

Specific-gravity readings should therefore be taken at frequent intervals, and in this connection one cell only of the battery can be chosen as a pilot cell, and the condition of this may be taken as being representative of all the cells in the battery.

It is not possible to give a hard-and-fast rule as to how often specific-gravity readings ought to be taken, but if the battery is in continual use and also must deliver *high*-rate discharges, such as for engine-starting and undercarriage operation, a reading on the pilot cell should be taken before each flight. In the case of one particular aeroplane, the Peto & Radford Dagenite batteries are fitted with an extension tube in each pilot cell, so that a quick specific-gravity reading can be taken without having to disturb the battery cover, connections, or hold-down device. The fully charged specific gravity of the battery in question is 1·270, and it was found that a drop of 40 points in the reading could be allowed for safe operation of the undercarriage. A special hydrometer is supplied consisting of the usual glass barrel and rubber squeeze-bulb, but instead of utilising an ordinary hydrometer float the glass barrel holds a coloured spherical float which is calibrated to sink in acid weaker than 1·230 specific gravity. Whenever the operator takes a reading, therefore, he can tell at a glance if the battery has the requisite safe amount of charge by seeing if the coloured float sinks or floats in the acid extracted from the pilot cell.

It is advisable, therefore, for each individual operator to fix an optimum specific gravity depending on the conditions attaching to any one aeroplane. This specific-gravity reading can usually be arrived at by trial and error, or else by consultation with the actual battery makers.

It is good practice to remove the batteries from the aeroplane once a week for a full recharge on the bench, and in this connection a spare set of fully charged batteries should always be available for each aeroplane, so that a quick weekly change-over can be made.

The spare batteries are also available should any flight result in an undue drain on the batteries, thereby reducing the specific gravity below the previously calculated safe minimum figures.

Re-charging

Whenever it is necessary to remove the batteries from the aeroplane for a complete recharge, charging should be carried out at the normal rate until the specific-gravity and voltage readings remain constant for half an hour as indicated by two successive readings taken at fifteen-minute intervals.

It is important to take voltage readings when the charging current is flowing. Individual cell voltage readings should not be less than 2·6 volts taken with the normal charging current flowing.

In hot climates, or when the cell temperatures rise above 100° F., recharge correspondingly longer at half the normal rate.

The capacity of a battery is usually stated as being so many ampere-hours at a given rate of discharge in hours, and this capacity is a measure of the capabilities of the battery and forms a basis of comparison between batteries. The capacity is the product of a steady discharge current in amperes and the stated time of discharge in hours. For instance, a battery rated at 70 ampere-hours at the 20-hour rate will discharge continuously at $3\frac{1}{2}$ amperes for 20 hours to a prescribed final voltage, which is usually 1·80 volts per cell.

If the normal charging current is not known, a safe guide is to divide the capacity of the battery at the 20-hour rate by 10 in order to arrive at a normal charging current. Therefore in the case of the previous example a reasonably safe normal charging current would be $\frac{70}{10} = 7$ amperes.

When charging a battery, and also when installing it in the aeroplane, it is most important to take care that all connections to the battery are perfectly tight so that there is no chance of sparking occurring. Also see that the nuts on all bolted inter-cell connectors are well tightened down.

General Maintenance

Keep holes in the vent plugs clear.

Keep the vent plugs well screwed home.

Never bring a naked flame near to batteries on charge.

Always switch off the battery circuit before making or breaking the battery connections, both in and out of the aeroplane.

Keep the top of the battery clean and free from dust or moisture.

Keep the terminal parts well smeared with vaseline.

Storing the Battery

In cases where the aeroplane is out of use for long periods at a time the battery should be treated as follows :

If it is to be out of use for not more than three months, give it a normal charge, check the final specific gravity, and adjust if necessary. Short freshening charges should then be given at intervals of not more than six weeks. Before being put into service again, it should once more be brought to a fully charged condition.

If the battery is to be stored for a longer period than three months the following should be carried out : Fully charge it and then pour and drain off the acid, wash the cells out with distilled water two or three times, and drain off again all liquid from the cells. Do not leave water in the cells.

The vent plugs should then be screwed tightly down. After the final draining the vent plugs should be replaced within, say, ten minutes, otherwise the negative plates will probably suffer damage.

To put into service again, fill with acid as described in the makers' instructions dealing with first charge, and immediately charge at the normal rate until fully charged indications are reached.

IGNITION SCREENING HARNESS FOR AERO ENGINES

THE widespread use of wireless telegraphy has brought with it the necessity for shielding or screening the ignition circuits, due to the interference caused by the ignition system of aero engines.

The terms shielding and screening may be defined as a bonded or earthed metal sheath housing the entire ignition system, thus confining the electrical fields.

On medium wavelengths, suppression of the interference is not essential for telegraphic or telephonic reception, but for short-wave services on long-distance aeroplanes, suppression is, of course, vitally important.

Of secondary importance, screening of the ignition wiring system is designed to minimise the risk of fire, and to provide protection of the high-tension cables against mechanical damage and deterioration such as may arise from contact with oil.

During recent years a considerable amount of work has been done to ensure that radio reception is practically free from interference caused by electrical apparatus on the aeroplane, so that communication on any wavelength and with the most sensitive type of apparatus is possible in the air.

There are, however, many instances where the work of suppression leaves much to be desired. Of course, there are aeroplanes, particularly when privately owned, whereon radio apparatus is not carried. In such cases the owners may be unaware of the interference which their crafts produce in flying, for example, on a parallel course with other aeroplanes, or of the annoyance caused to television viewers on the ground when the aeroplanes circle over their aerials.

It may be of interest to mention that on the fringe of the television service area, i.e. above 40 miles from the television transmitter, interference from the ignition circuits on aeroplanes and automobiles is one of the limiting factors in good reception, as these circuits can radiate on the wavelengths used for the television and other short-wave services and often produce intense disturbance on visual and aural reception.

Causes of Interference

It is, of course, common knowledge that the ignition system is the chief source of interference because of the high-voltage spark and

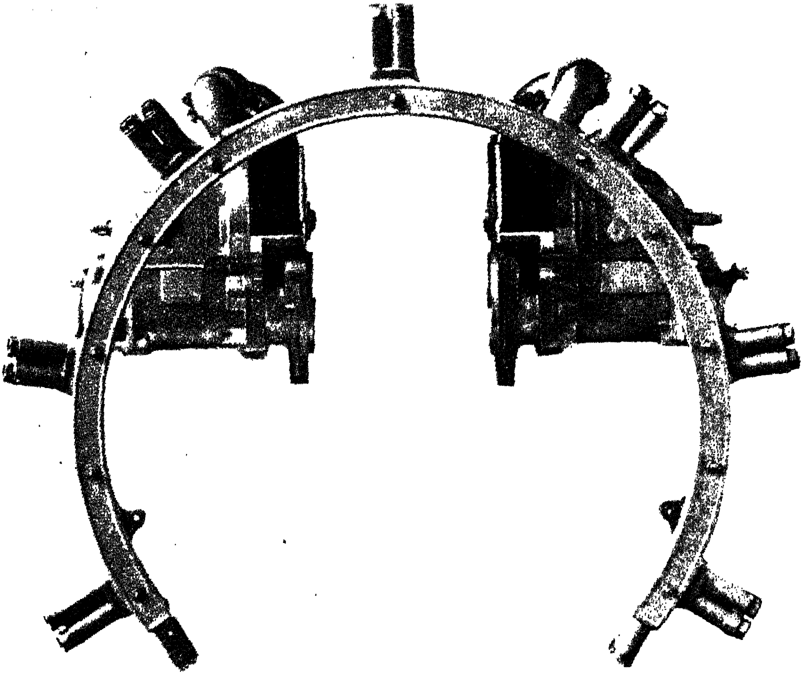


Fig. 1.—B.T.H. HARNESS SYSTEM

This manifold system can be bolted rigidly to the engine and forms a complete screen for the H.T. cables from the magnetos to the outlet points which are disposed to allow of short, flexible screened cable connections between the manifold and screened plugs on the cylinder head.

resultant high-frequency disturbance which is generated. Each spark produced at the distributor and plug points results in the generation of H.F. currents which flow in the associated conductors at a rate determined by the distributed inductance and capacity of the circuit. In other words, the circuits have natural time-periods which control the frequency of the oscillations and in this respect is analogous to the mechanical tuning-fork.

In some ways it is fortunate that the H.T. cables are relatively short and therefore radiate only at very high frequencies, corresponding to wavelengths of between 1 and 10 metres (300–30 megacycles). Radiation from the cables at these ultra-high frequencies may produce interference over an area of many miles. Needless to say, reception on these short waves in the air is practically impossible unless suitable precautions are taken.

The interference is not confined, however, to ultra-short wavelengths but may extend over the whole range of communication frequencies, although the disturbance is normally less intense as the receiver is tuned to wavelengths of lower frequency.

This reduction in interference as the wavelength is increased is due to the selectivity of the tuned circuits in the receiver and also to the inefficiency of the H.T. cables as radiators at lower frequencies. Consequently, for a given installation, the coupling between the ignition circuit and the radio aerial is automatically loosened as the signal frequency is reduced. If, however, the receiving aerial is moved very close to the ignition circuit, the interference will increase irrespective of the natural selectivity of the circuits.

There are two explanations for this phenomenon. One is the "shock" effect produced on any tuned system, whether electrical or mechanical, by the energy *suddenly* liberated in the ignition circuit immediately following the ionisation between the spark points, i.e. like a hammer blow in a mechanical system.

The phenomenon can also be explained by considering the nature of the complex wave-form produced by the ignition spark. This wave-form can be split up by analysis and is known to contain voltage components covering a wide range of frequencies, consequently exciting any circuit, irrespective of the frequency to which it is tuned. The low audible frequency which is heard after rectification in the receiver is the characteristic or spark frequency, by means of which one may readily identify the source of a disturbance—for example, distinguish between a magneto and an electric motor. In each case, however, the interference-producing voltages are generated in the circuit by the sudden interruption of the current when the spark has occurred.

All other spark- or arc-producing devices cause interference in much the same way, but differ with respect to the intensity of the disturbance on account of the lower operating voltages employed ; also, the marked radiating and resonance characteristics of the ignition circuits are not so pronounced in other circuits and, if present, occur usually at some lower frequencies. Interference from low-voltage circuits may, however, be just as disturbing as from the ignition circuit, because of the closer coupling which usually exists between them and the aerial system on aeroplanes.

The coupling between the source of interference and the aerial system is, in fact, not entirely dependent upon the physical spacing between them.

The H.F. disturbance may be induced into any other circuit or conductor which may be in close proximity with, say, the ignition circuit at one end and with the receiving aerial at the other, thereby in effect coupling more closely the two circuits and so increasing the interference.

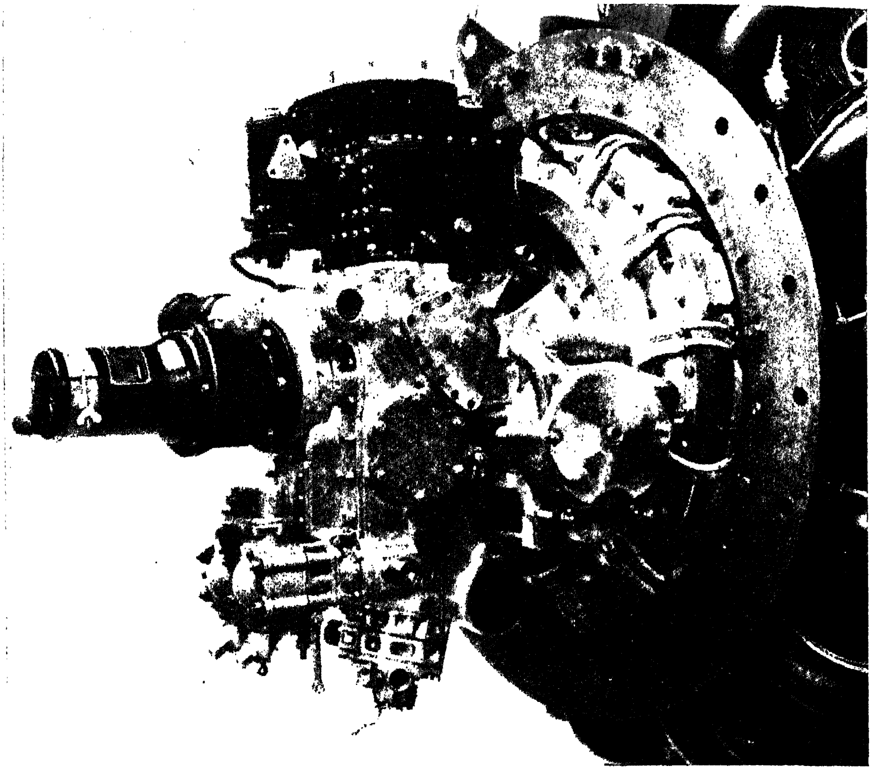


Fig. 2.—Complete harness assembly

The complete harness is here shown fitted to an engine.

How Interference affects Different Receiving Systems

Having now briefly outlined the cause and nature of the interference, there remains to be described the methods of suppression which are available; but before doing so it is desirable to explain how different communication systems are affected by electrical interference.

In the case of telegraphy, the listener will usually be a trained operator, skilled in the art of distinguishing between the wanted and unwanted sounds and able to receive a message through a medley of interference, probably as strong as the signal itself. In addition, radio-telegraphic receiving apparatus is designed to be far more responsive to the signal than to interference by virtue of the greater selectivity permissible in the radio- and audio-frequency channels respectively of the receiver.

The case of radio-telephonic reception is more difficult, for so much will depend upon the clarity and strength of articulation and the fact that the listener may be inexperienced. Moreover, a receiver designed for telephonic reception is inherently more sensitive to interference because it must pass a wider band of frequencies through both radio and audio circuits in order to reproduce intelligible speech.

Therefore the signal/interference ratio must be relatively high ; for example, in the broadcast reception of speech or music, " interference-free " may be defined as the condition obtaining when the interference is practically inaudible in the presence of the signal—that is, the speech or music produced by the signal as compared with the aural disturbance produced by the interference should correspond to a voltage ratio of 100 : 1.* However, for communication purposes a lower ratio than this may be permissible.

In regard to all other radio-operated appliances which do not produce aural effects, e.g. course and landing indicators, there is, of course, scope for the use of highly selective circuits, in every stage of the apparatus, to obtain the maximum discrimination between the signal and interference.

The disturbing effect of interference may also be influenced by the following : Wavelength employed, distance from transmitter or strength of signal, the type and position of the receiving aerial and constructional features of the aeroplane.

Methods of Suppression

Considering only the ignition circuit, there are two recognised methods of suppression.

(1) By damping or filtering the circuits.

(2) By partial or complete screening of the circuits, plugs and magnetos.

The first method consists of reducing the radiation of the H.F. disturbance from the exposed circuits by the insertion of resistance units at one or both ends of each H.T. cable or by making the conductor itself of some resistive material, i.e. distributing the resistance throughout the length of each cable. Alternatively, small radio-frequency choke coils may be inserted at the ends of the H.T. cables instead of the resistor units. The " damping " of the circuit by the resistance method is the preferred arrangement, because it prevents sustained oscillation and radiation from the conductors at any frequency, whereas the choke or filter method will protect only the selected frequency band determined by the impedance characteristic of the choke coil and circuit.

Nearly twenty years ago it was proposed to use H.T. conductors constructed of links like a chain, in which the electrical contact between each link was made through a film of graphite or other resistive material. The object in view was no doubt to retain the mechanical strength of the conductor, but as far as is known the scheme was never developed outside the experimental stage.

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* See B.S.S. 800, Appendix A.

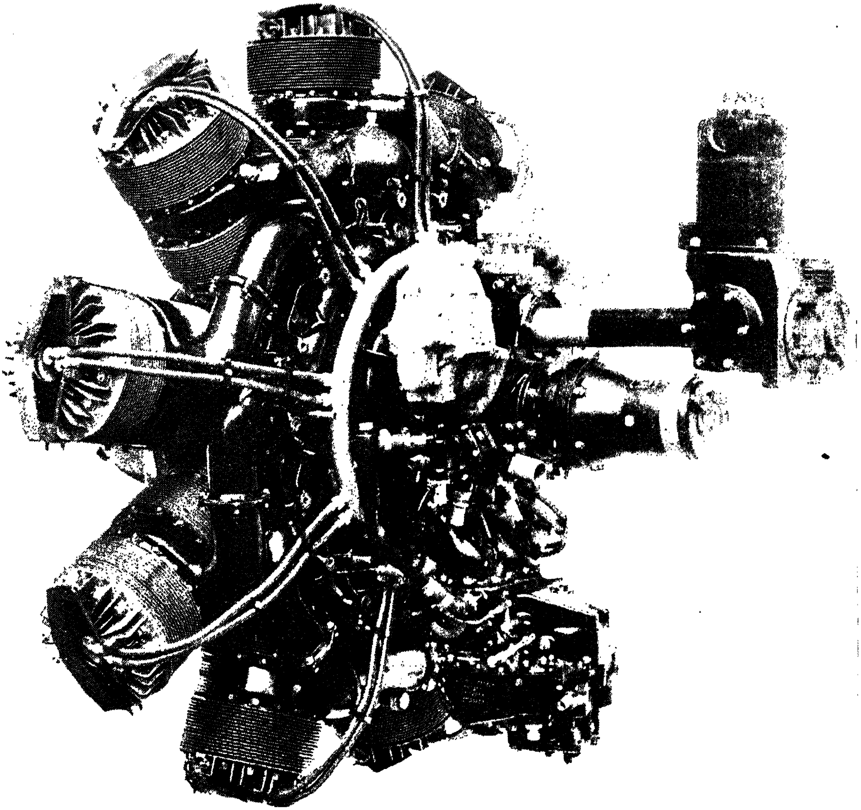

Fig. 3.—The H.T. screening system on the Bristol "Perseus"

The above method has, more recently, been very fully investigated by the British Electrical Allied Industries Research Association* in connection with the suppression of ignition interference on automobiles, and whilst it has been proved quite satisfactory when applied to motor-cars and the like, there are certain objections to its use on aero engines. Apart from the fact that it does not afford complete protection from interference in flying, particularly on the shorter wavelengths, there is also the danger of impairing the efficiency or working of the ignition system in its vital service through the deterioration or failure of the components used. Moreover, some believe that the added resistance in the H.T. circuit of between 10,000 and 20,000 ohms does impair the performance of an engine by adversely affecting the ignition spark.

Finally, the aero-engine maker has a good case against the fitting of these additional " bits and pieces " somewhat precariously suspended, maybe, in the circuit connected to a high-speed aero engine. It is not proposed, therefore, to go into the details of this method, which it is suggested, however, could be developed and made suitable for application to machines not fitted with radio apparatus or where complete suppression was not required, e.g. for long-wave reception and where the signal was always strong, thus providing a satisfactory signal interference ratio.

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* See E.R.A. Reports, M/T28 and M/T47.

Screening Methods

Screening the ignition system was introduced on aeroplanes during the War of 1914–18 and has been extended and improved as radio receiving requirements demanded. Each H.T. cable was covered with a flexible metal braiding, bonded at each end to the engine. Screened plugs were then introduced and later the distributor in the magneto was included in the screening system. Finally, both the H.T. and L.T. cables, where used, were completely screened with this flexible metal braiding. Enveloping the H.T. cables in a metal sheath was equivalent to connecting a condenser in parallel with the spark gap, and this introduced a load on the magnetos which very few makes were capable of meeting without the risk of failure. Consequently, in these early days there was some objection to the screening method.

The necessity for reliable communication in flying, especially on short wavelengths, made some form of screening essential, with the result that all aero magnetos were designed to stand up to the additional loading introduced by the screened cables.

Some of the first serious attempts made in England to tackle the interference problem were probably those of the Marconi Company in 1920 in co-operation with the K.L.G. Co.; a sparking plug was developed with a screening cover which was used in conjunction with high-tension cables covered with a closely woven tinned copper braiding.

A number of engines were fitted with this screening equipment with useful results.

Effect of Screening on the Interference

The presence of a screen around any circuit tends to " damp " or neutralise the high-frequency disturbing currents flowing in the conductors within the screen.

In the case of long screened cables, however, this action is dependent upon the screening member being connected at short intervals in its length to the solid mass of the engine or chassis and thereby maintaining at equipotential every point on the screen. This " bonding," as it is called, plays an essential but often neglected part in the suppression of interference. It is also important for other reasons, which will be described later. The effectiveness of the complete screening method depended largely on the care with which the installation was handled.

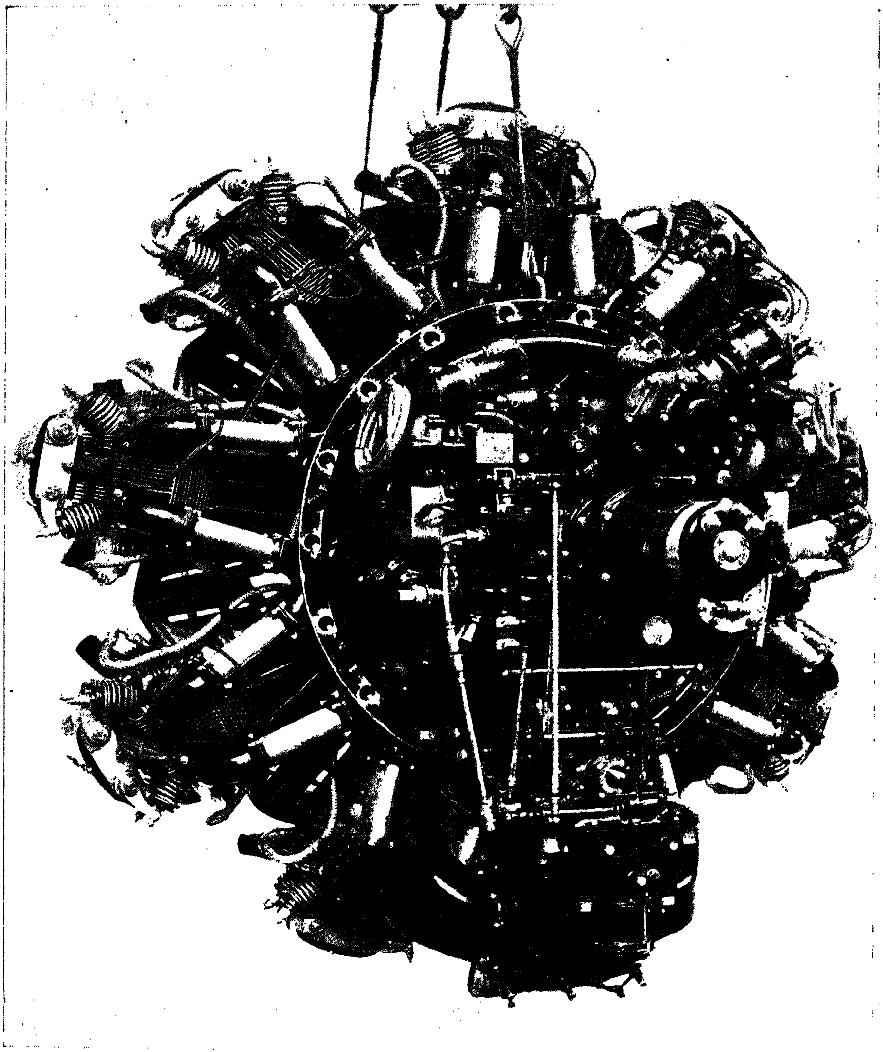


Fig. 4.—SCREENING HARNESS FITTED TO BRISTOL "PEGASUS" ENGINE
(*By courtesy of the Bristol Aeroplane Co.*)

Loose terminals and bonding connections often defeated the object of the screening, whilst from a mechanical standpoint long lengths of braided cable often caused trouble in service through fractures in the braiding, resulting in the deterioration of the rubber cable ; also the risk of ignition failure through broken wires turning in and puncturing the insulation was ever present.

In recent years these difficulties and dangers have been largely overcome by a much better mechanical arrangement, which is known as a " harness," no doubt familiar to most readers.

The development of the modern harness was commenced in America, and the quick development of the American type harness as a safe and serviceable assembly was undoubtedly due to the active co-operation between the American Bureau of Standards and other government departments, research laboratories and manufacturers.

The American Bureau of Standards first evinced interest in shielding experiments in about 1926. The Navy Department later became interested and, in co-operation with an American company, developed a shielded plug.

Active work was carried on up to about 1930, by which time sound and practical harness for various types of engines had been evolved. Harness is now available for most types of American engines, and there are several large corporations specialising in its manufacture.

During the course of the experimental work it was found that the difficult part of the problem was to produce shielding equipment which was mechanically and electrically sound, so that the engine reliability was not prejudiced, and also sufficiently robust and simple to please the engine people.

Most of the American aeroplanes seen in England are equipped with fully screened ignition systems, and for the few not fitted standard equipment is available if required. Many of the Continental air liners also are so fitted.

The Marconi Company, in co-operation with the Bristol Aeroplane Company, was first to develop and standardise a design which met the Air Ministry's stringent requirements, and is now occupied in bulk manufacture for various types of engine.

The harness system provides both mechanical and electrical advantages as follows. It facilitates installation and is easily adaptable to all types of engines, affords greater protection to cables and is more reliable in service. As all the cables are run for the greater part of their length inside a solid tubular metal casing, the screening and bonding are more effective and the capacitance loading on the magneto is reduced. Short flexible lengths of braided covered cable are, however, necessary for connection to the plugs, but these screened cables are now of improved construction and provide double screening and afford greater protection to the cable insulation from the ingress of oil and moisture.

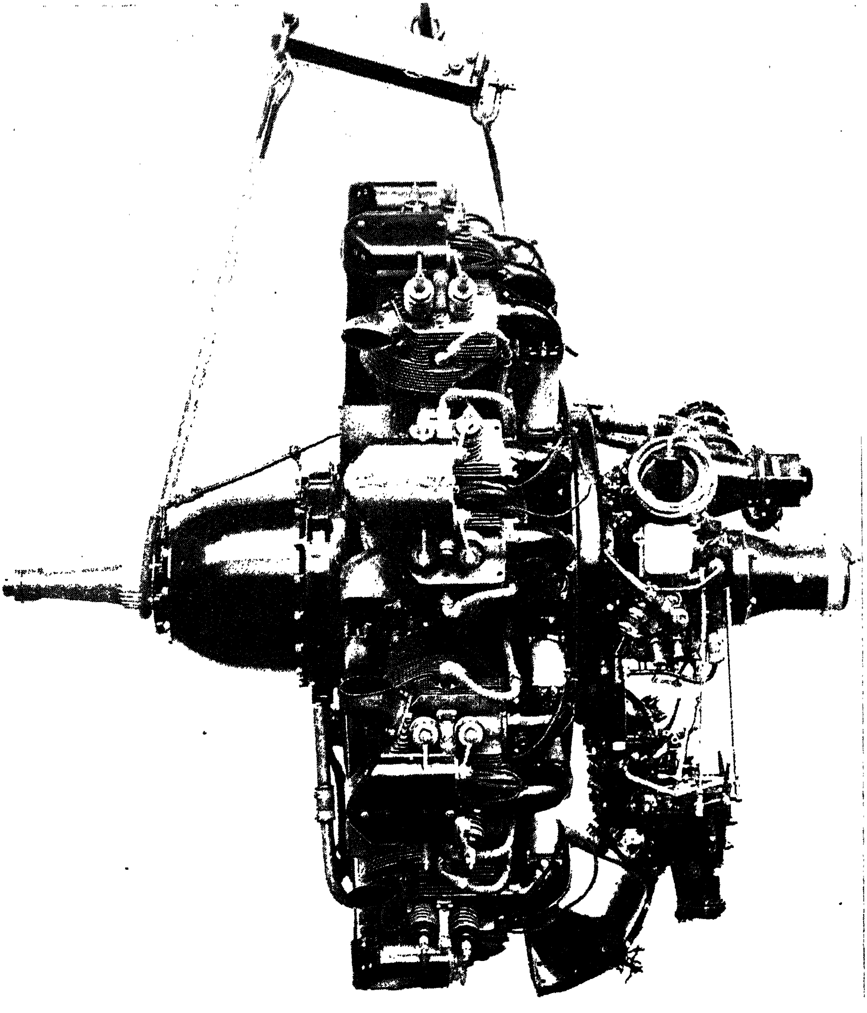


Fig. 5.—Another view of the screening harness fitted to Bristol "Pegasus" engine

(*By courtesy of Bristol Aeroplane Co.*)

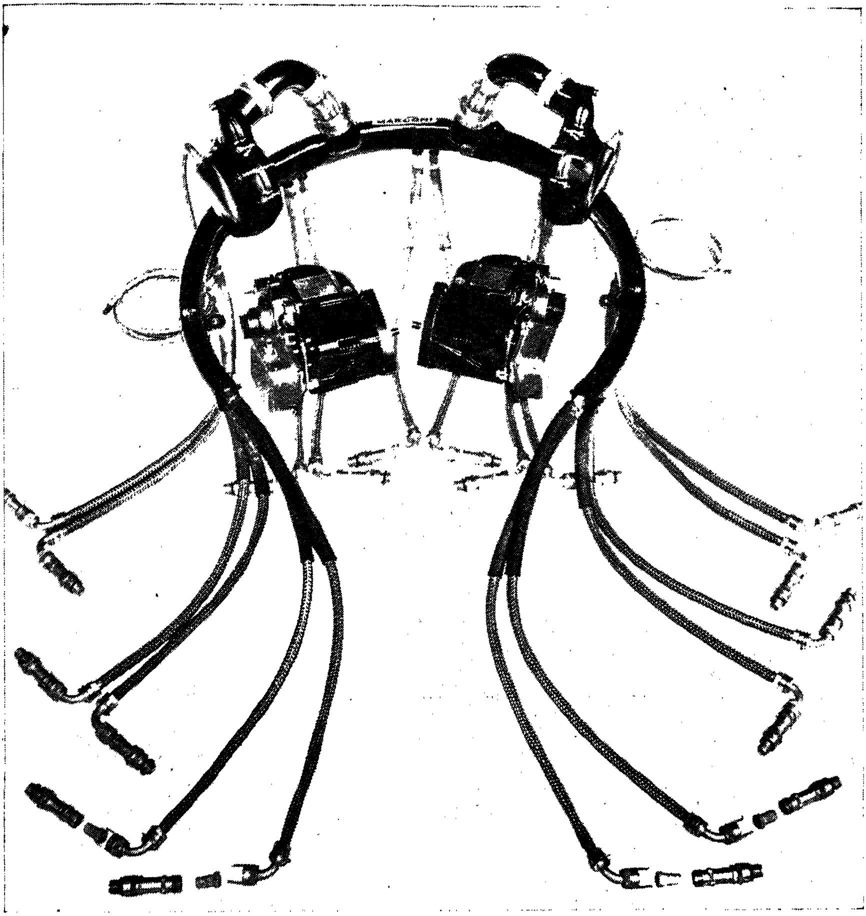


Fig. 6.—MARCONI HARNESS FOR BRISTOL "PEGASUS" ENGINE

The whole arrangement looks very simple and effective, which indeed it is, always providing the installation is fitted in a manner which ensures that every point of contact with the engine makes good and *permanent* electrical connection and all the joints and bonding connections are tightened or locked to withstand the vibration in service and so maintain all parts of the screen substantially at the same potential.

The Present System of Ignition Harness

Owing to the proprietary nature of design and supply, types of ignition screening may vary considerably in the arrangement of details, but, broadly speaking, the screening harness may be said to be made up of the following parts, viz.:

(*a*) The body of the harness, or main duct, in several parts, joined by means of screwed or conical mortise joints. The materials in common use for these ducts are brass, aluminium, or copper. The fixing of the harness to the engine is effected by means of brackets soldered or brazed to the ducts.

(*b*) The flexibles leading from the ducts to the magneto, covered with a metallic braiding of close mesh, made of tinned copper wire or tinned phosphor-bronze wire. The inner metallic tubing is of interlock section, in either aluminium, brass, or copper.

(*c*) The flexible tubes for attachment to the sparking plugs, of a similar structure to that of the magneto flexibles.

(*d*) The distributor cover of the magneto, in aluminium, brass, or copper. (At this stage it should be emphasised that magnetos which are not screened in manufacture present a problem to the designer of the ignition screening harness, for even with the most scrupulous care the surfaces to be joined cannot be in perfect contact, particularly in the case of curved or awkwardly shaped parts ; as a result, the screening of the circuit as a whole will be doubtful.)

Theoretically, therefore, we have the complete ignition system enclosed in a metallic envelope, forming a Faraday cage. In practice, however, numerous difficulties present themselves to the harness designer in order that he may make the mounting and dismantling of the harness a simple and speedy operation.

THE T.I. SYSTEM OF IGNITION SCREENING HARNESS

Messrs. Technical Improvements, Ltd., produce a screening apparatus that has been progressively tested and improved over a number of years.

The T.I. Harness, as it is universally known, is now supplied to Imperial Airways, Armstrong Siddeley, Ltd., Alvis, Ltd., Air France, De Havilland Engines, and leading Continental aero engine manufacturers and air-line operators.

The following points have been especially considered in its design and manufacture :

(*a*) Efficient and durable protection from parasitic waves and interference. The reduction of electrical capacity in order to maintain the magneto efficiency.

(*b*) Ease of mounting and dismantling the harness on or from the engine.

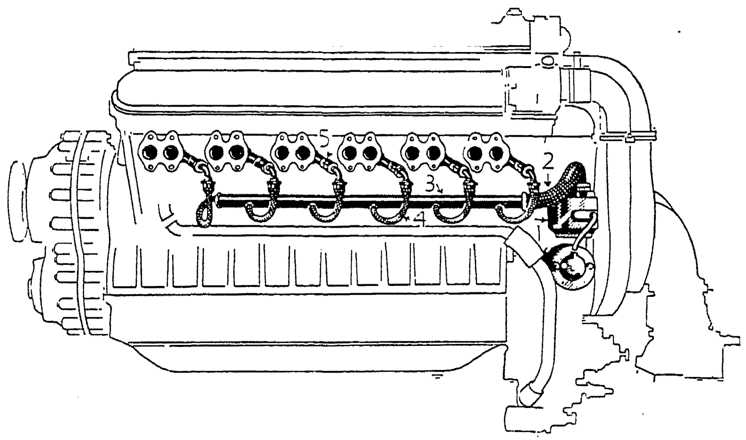
(*c*) Standardisation of elements to simplify and cheapen replacements.

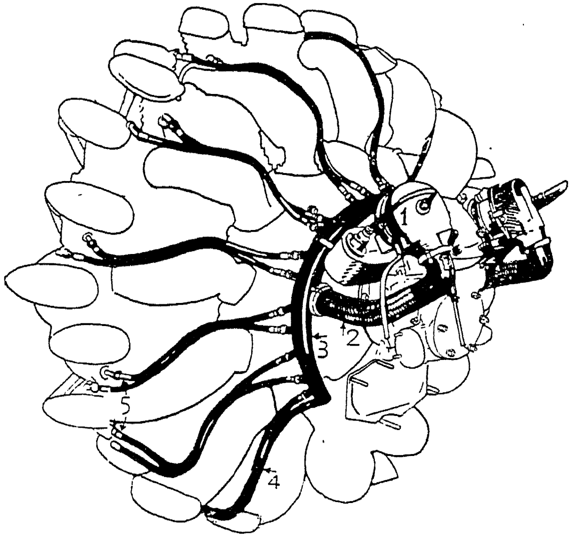
(*d*) The reduction of weight to a minimum.

General Characteristics of the T.I. Harness

The characteristics of the T.I. system may be summed up as follows :

The high-tension leads from each magneto are led through tubular ducts connecting the magneto frame to the main duct, and from this main





1. Screened Magneto.
2. Magneto flexible outlet.
3. Main duct.
4. Plug flexibles.
5. Screened plugs.

Fig. 7.—THE T.I. SYSTEM OF IGNITION SCREENING HARNESS
(*Technical Improvements Ltd.*)

channel branch off to the various sparking plugs through flexible metallic tubes, which are coupled at one end to the main duct and at the other end to the plug elbow.

Plain high-tension cables of 7 mm. diameter over the covering are used in place of screened cables of 9·5 mm. diameter. This reduces the assembly space, the weight and the length of leads ; the screening structure is less bulky, and its clean symmetrical outline greatly enhances the general appearance.

Description of the T.I. Harness

The T.I. screening harness comprises three major parts :

(1) The body or main duct.

(2) The tubular connections to the magnetos ; these tubes are partly or wholly flexible.

(3) The flexible metallic tubes for attachment to the plugs.

The advantages resulting from this arrangement are as follows :

(*a*) The elimination of faults inherent to metal-braided high-tension cable.

(*b*) The reduction of electrical capacity, since the space between the high-tension conductor and the metallic tubular covering is increased.

(*c*) The easy and economical replacement of single cables.

(*d*) The contact to "earth" increased by the bracket attachments of the ducts to the engine frame.

Some Design Problems in Harness Construction

(1) *Proofing Against Liquids*

One problem that the designers of ignition screening systems have to face is the question of proofing against liquids. Complete protection against penetration of oil or petrol can only be obtained by introducing a dangerous element : gas-tightness.

In a harness which is absolutely gas- and watertight, the passage of a current of very high frequency in the cables produces a certain quantity of ozone which combines with the ozone emanating from the distributor of the magneto and which cannot be dispersed. The result is, in spite of the use of varnished cables said to be "ozone proof," that the rubber of the cables deteriorates very rapidly by the corona effect in the bent parts.

Theoretically, it was believed that it was possible to minimise these inconveniences by reducing the number of the curved parts and increasing their radius of curvature. That is a fallacy. One cannot ignore the fact that nothing governs the position that the high-tension cables take up in the interior of the duct when passing through the tubing of a harness, where they frequently become twisted, that is to say, in the most favourable position for the corona effect.

The only real remedy for this state of affairs is to allow the ozone to be dispersed by renewing the air, and for this purpose the designers of the T.I. system provide apertures in the lower and upper parts of their harness assembly, and in the magneto flexibles, which allow condensed vapours to disperse, in addition to providing the effect mentioned above.

Therefore, the problem of proofing as regards liquids is a question of secondary importance, the primary consideration remaining that of good electrical contacts and the reduction of electrical resistance at the joints.

(2) *Screwed Joints*

Another problem is that of bringing two plane surfaces together by means of nuts. It was not possible to ensure sufficient guarantee of the surfaces in contact being cylindrical and fitting together, or that conical surfaces gave proper penetration. Particularly in the case of cylindrical surfaces, undoing the nut could give rise to a slight displacement of the two parts in relation to one another. A nut which has not been tightened properly gives rise to bad disturbance, which is recorded on radio reception and transmission ; on the other hand, a doubtful contact between two plane surfaces gives rise to just as bad a result.

On the T.I. system, the screwed joint is eliminated wherever possible, and conical or other sleeve joints are used, thus ensuring a better "continuity" and more efficient radio reception. The junctions between the magneto elbows and the main ducts are effected by means of male and female couplings : split collars held by strip clips tighten on to the couplings and pull the cone joint together.

(3) *Earthing Joints on Plug Flexibles*

It is a practice, noticeable on certain designs of ignition screening harness, to arrange earthing joints along the flexible leads to the sparking plugs in view of their great length. This method prevents covering the metallic braiding of these flexibles by insulating material along the whole length. The necessity for these earth connections is problematical, except for use with ultra short-wave reception, but there is every reason for fearing that successive loops formed in this way impede the flowing to earth of the currents induced by the screening.

Again, these additional earth connections may become unsoldered in flight, and will then radiate like aerials. On the other hand, the metallic braiding will not constitute an effective screening unless it is of a very tight mesh, and the contact between the various wires of the braiding is perfect. Also, the parts denuded of the braiding will gather oil to a great extent. This oil, brought to a high temperature in the neighbourhood of the cylinders and exhaust pipes, will transform itself into a kind of insulating varnish, which will then materially reduce the effectiveness of the screening.

The designers of the T.I. system have, however, overcome this problem, and cover the plug flexible tubes with a textile braiding throughout their length ; this is covered in turn with a special varnish. The advantages of this practice are obvious.

General Maintenance Instructions for T.I. Harness

As the T.I. harness is now supplied to most of the leading aero engine manufacturers, the following instructions may be useful to those responsible for the fitting and maintenance of the system :

Fitting Instructions

(1) Disconnect all couplings by removing clips and collars.

(2) Fit harness to engine by means of suspension brackets.

(3) Fit collars and clips on main duct couplings, without straining ducts, and tighten clip screws.

(4) Tighten nuts on harness brackets.

(5) Withdraw distributor plates from distributor covers as allowed by the slack of the high-tension cables, and fit the distributor connectors carefully in the distributor mouldings (this is important).

(6) Place the distributor covers on the magnetos squarely, and fit and tighten bolts provided.

(7) Fit collars and clips on magneto flexible elbow couplings, without straining ducts, and tighten clip screws.

(8) Tighten nuts on plug flexible tubes, using special spanner supplied by the harness manufacturers for this purpose (Ref. No. T.I. 1198).

(9) Fit plug leads in clips on engine, and connect to sparking plugs. *Note.*—Plug nuts must be tightened with spanner. Finger tightening is insufficient.)

Removal of Harness from Engine

Reverse fitting instructions as far as possible.

Replacement of Faulty High-tension Lead

It is not necessary to dismantle the harness when replacing high-tension leads, for which the following procedure should be adopted :

(1) Disconnect couplings from the necessary flexible magneto elbow by removing clips and collars.

(2) Remove bolts in distributor cover and remove cover from distributor plate.

(3) Remove distributor plate from moulding and disconnect old wire at distributor end.

(4) Strip ends of old and new wires and sweat together at distributor end.

(5) Disconnect old wire at plug end and remove plug elbow and flexible tube.

(6) Pull new wire through nipple by means of old wire.

(7) Break sweated joint between old and new wires, fit flexible tube, plug elbow and plug connector to new wire, reconnect to sparking plug.

(8) Connect up new wire at distributor end.

(9) Refit distributor plate, distributor cover, and flexible elbow.

(10) Refit collars and clips on flexible elbow couplings and tighten clip screws.

Notes.—*(a)* The use of powdered French chalk on the high-tension cables facilitates the pulling-through operation.

(*b*) Care must be taken, when fitting plug and distributor connectors, to avoid cracking insulators.

(*c*) Plug flexibles must not be fitted or removed without slackening terminal nuts at duct end.

ELECTRICAL TESTS ON IGNITION SCREENING HARNESS

The following electrical tests, which cover all types of harness, should be carried out after final assembly. These tests are to be carried out in conjunction with any special instructions or additional tests that may be issued by the harness manufacturer:

(1) Continuity Test

Each ignition cable should show continuity when tested between the contact face on the attachment to the sparking plug and end of ignition cable contact to ignition apparatus, or, when attachments for sparking plugs are not fitted, between its extremities.

(2) Megger Insulation Test

A Megger insulation test should be taken between the conductors of the ignition cables and earth (as represented by the complete casing of the harness).

(3) High-voltage Test

The harness should satisfactorily withstand the application of a high-voltage test of 15,000 volts between the conductors of the ignition cables and earth (as represented by the complete casing of the harness).

(4) Resistance Test

An electrical resistance should be taken between specified points on the harness, the reading not to exceed the requirements of the relevant specification.

(5) Capacitance Test

An electrical capacitance test is required, and the capacity of each screened conductor should be approximately two-thirds of the value of capacitance of braided cable of equivalent length.

(6) Interference screening properties, when specified, should conform to requirements.

INSPECTION OF IGNITION SCREENING HARNESSES

The following inspection routine, which covers all types of harness, should be adopted as a general procedure in conjunction with any special instructions that may be issued by the harness manufacturer:

(1) Materials

The inspector should verify that all the materials used in the construction of ignition screening harness (including associated electrical fittings) conform to the relevant specifications.

(2) Manufacture

The inspector should verify that :

(*a*) All manufacturing processes, including heat treatment, welding, brazing, and soldering, have been carried out under the condition of the relevant specifications.

(*b*) All sharp corners and rough surface irregularities liable to damage the dielectric of the high-tension cables have been removed. (*Note.*—The importance of the rigid observation of this requirement cannot be too strongly emphasised.)

(*c*) Flexibility of the braiding and conduits has not been affected by the process involved in attaching the end connections.

(*d*) Detail parts and subassemblies satisfactorily withstand the application of high-voltage, immersion, and pressure tests as specified.

(*e*) Protective treatments have been correctly applied, and conform to the relevant specifications, drawing requirements, and/or inspection instructions.

(*f*) The standard of workmanship is satisfactory.

(*g*) Dimensions of all parts are correct.

(3) Assembly

(i) Prior to wiring of the harness, the inspector should verify that :

(*a*) All details have received prior approval.

(*b*) Screw thread and other jointing surfaces are free from burrs and damage.

(*c*) The bores of the main and flexible conduits, elbows, and detail fittings are clean, dry, and free from foreign substances. (*Note.*—Anodic or other protective treatments which increase the electrical resistance should have been removed from joint surfaces and threads.)

(*d*) Contact area of joint surfaces is the maximum practicable.

(*e*) Ignition cables are of correct length and of specified material, both for conductor and dielectric.

(ii) During the wiring of the ignition screening harness, the inspector should verify that :

(*a*) The dielectric or conductor of the ignition cable is not damaged during insertion through the main and flexible conduits.

(*b*) All strands of ignition cable are soldered effectively or otherwise brought into intimate contact at connection points when soldering is not specified.

(iii) After complete assembly of the ignition screening harness, the inspector should verify that :

(*a*) The high-tension cables have been correctly distributed for connection to the ignition apparatus.

(*b*) The ends of the high-tension cables bear the correct identification numbers and/or letters.

(*c*) The attachment of the flexible conduits to the main conduit or duct is secure, and the locking of parts is to specified requirements.

(*d*) The spring plungers, when fitted, are allowed free movement throughout their travel.

(*e*) The fitting and/or locking of the details on which the assembly of the harness depends are secure.

(4) Electrical Tests

The electrical tests to be carried out on ignition screening harnesses after complete assembly have been dealt with in the preceding pages of this article under the appropriate heading.

(5) Weight

The type harness should be first of all weighed as a complete unit, the subassemblies and details then being weighed as separate units.

The inspector should verify that subsequent harnesses of the same type do not exceed the weight specified.

(6) Final Inspection

The inspector should verify that :

(*a*) The harness is in conformity with the factors which affect interchangeability with its associated electrical equipment and assembly on the engine.

(*b*) The harness bears the specified type nomenclature, serial number, inspectional and other markings, correctly positioned.

(*c*) External surfaces, fragile fittings, and openings are protected in accordance with specified requirements.

(7) Inspection Records

The inspector should verify that the inspectional acceptance of each individual harness is recorded during each stage of manufacture and test. Inspection markings and/or records should cover :

(*a*) Accuracy of production of all details.

(*b*) Process and electrical tests on details and assembly.

(*c*) Accuracy of assembly of harness, including checks for interchangeability.

(*d*) Type and individual identification, locking of parts, general condition and completeness for dispatch, in accordance with specified requirements.

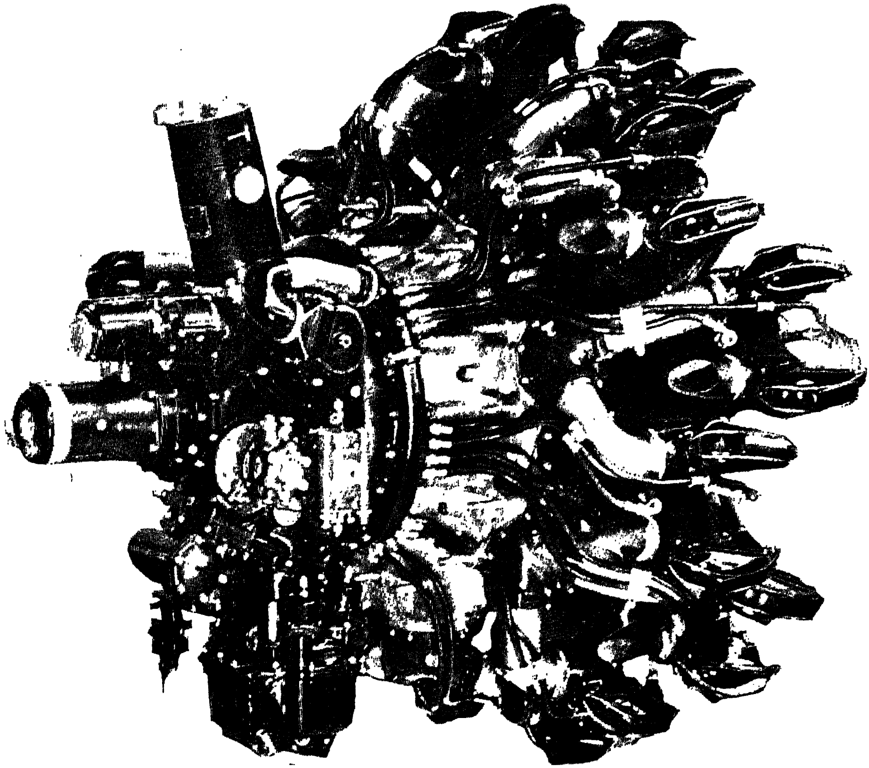


Fig. 8.—T. I. SCREENING HARNESS ON ALVIS 14-CYLINDER " PELIDES " ENGINE

(8) Assembly on Engine

After assembly on an engine and attachment of high-tension ignition cables to the distributor of the ignition apparatus, the inspector concerned should verify that the ignition cables are tested individually for continuity between the contact face on the attachment to the sparking plug and the corresponding segment in the distributor of the ignition apparatus.

SOME LAST WORDS ON INTERFERENCE

Particular attention is drawn to the concluding sections of this article which have, as will be seen, a reference to interference problems in general.

Bonding

The importance of good and permanent electrical connection between all component metal parts of the aeroplane cannot be overstressed,

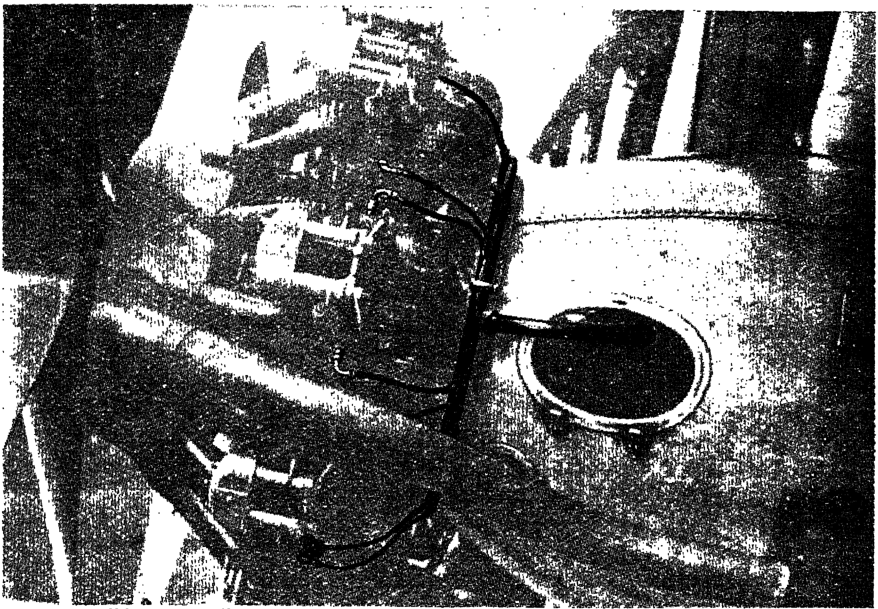


Fig. 9—T. I. SCREENING HARNESS FITTED TO "JUPITER" ENGINE

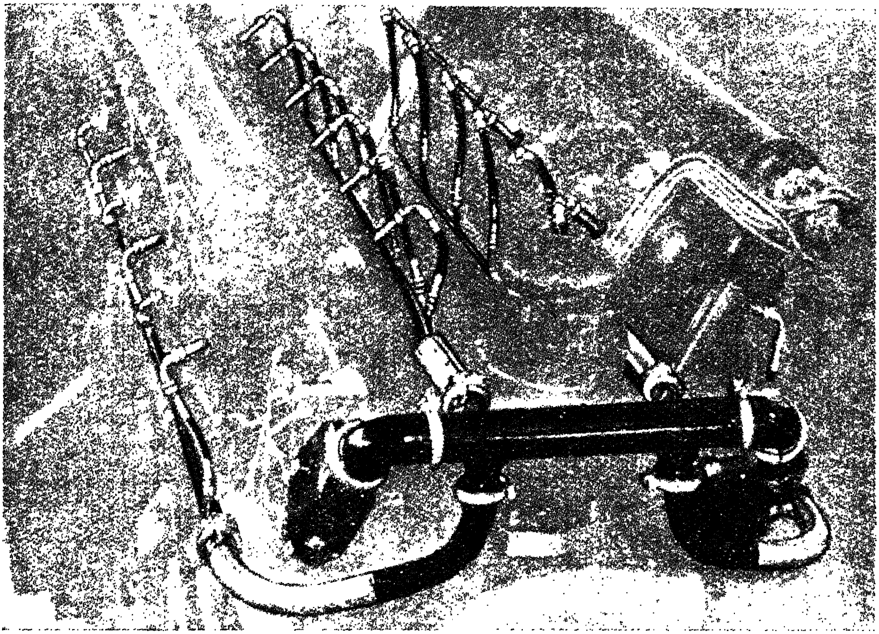


Fig. 10.—T. I. SCREENING HARNESS FITTED TO "HISPANO-SUIZA" 12-CYLINDER ENGINE because in most radio installations they form part of the receiving circuit, i.e. the counterpoise to the aerial or the "earth" equivalent. Any variation in the electrical resistance between one part of the aeroplane and another may therefore produce results similar in effect to those produced by a switch in the aerial circuit being opened and closed very rapidly. Similar results may also be produced by bracing wires, control wires or rods and other metallic bodies capable of making vibratory contact with one another.

Poor bonding or any change in the electrical condition of the metalwork in the aeroplane is usually more noticeable in short-wave reception, and a point is reached when screening or interaction between the metal parts and tha aerial may produce serious loss in signal strength. This is because metel parts of the aeroplane which are comparable in length with the aerial behave as absorbers of the signals and may in fact completely blot out the signal arriving from certain directions in flying. The phenomenon is, of course, a form of interference not usually encountered in ordinary communication, but it is nevertheless worthy of mention.

From the foregoing it should be clear why good bonding is so necessary, but even when the receiving circuit is not directly connected to the chassis or frame of the aeroplane, e.g. where a loop aerial is used, the close proximity of the aerial system to the metal work in the plane necessitates similar precautions being taken.

Because defects in bonding can usually be detected only when flying and because the interference thus produced may be hard to distinguish from ignition interference due to similar periods of vibration, it is worth while paying close attention to the initial bonding methods employed and to ensure its maintenance in service through frequent inspection.

Defects in Wiring, Plugs, and Switches

A final word on the importance of *maintenance* work on all electrical circuits in aeroplanes, if only to prevent interference through loose connections in the wiring or loose-fitting plugs and sockets in any auxiliary circuit which may cause continuous or intermittent sparking. Whereas in the ignition circuit the spark is necessary, it becomes a defect in a lighting or other auxiliary circuit and should be prevented by an efficient inspection and maintenance service.

No mention has been made of the many other devices which now form part of the electrical equipment on aeroplanes and which are frequent sources of interference; but if the reader wishes to acquaint himself with the identity of these devices, he cannot do better than refer to British Standard Specification No. 613, which gives a comprehensive list of apparatus known to cause electrical interference and includes recommendations for its suppression.

Interference Measurement

Apparatus has now been developed by the Post Office * and E.R.A.† for the measurement of interference producing fields and voltages at practically all communication frequencies. It is therefore possible to make systematic and scientific investigations on any electrical interference problem in or out of the aeroplane with calibrated apparatus which can be relied upon to give accurate and consistent results.

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* See B.S.S. 727.

† See E.R.A. Reports, M|T45 and M|T60.

CARE AND MAINTENANCE OF SPARKING PLUGS

IF an engine is to give its best performance under all conditions and loads, it is essential that attention should be given to the cleanliness and condition of the sparking plugs, both from an external and internal aspect.

Modern engine conditions, combined with leaded fuel, affect the internal mica insulation to a very much greater extent than those of the lower-duty engines of earlier design. The complete removal of lead deposits from the surface of the mica and the maintenance of correct gaps are essential.

We are indebted to Messrs. Smith's Aircraft Instruments for the following notes on the care and maintenance of K.L.G. sparking plugs.

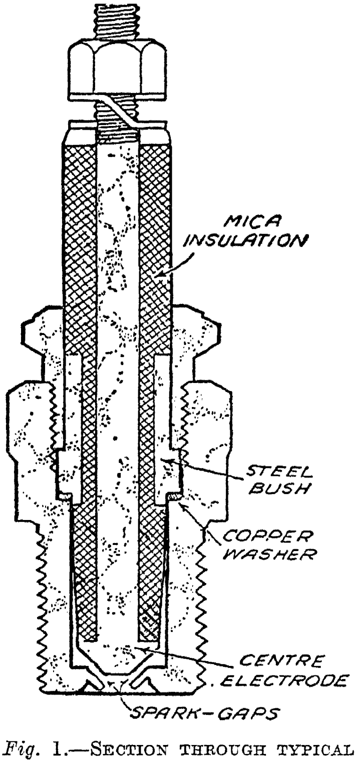


Fig. 1.—SECTION THROUGH TYPICAL SPARKING PLUG

Removal and Preliminary Examination

Remove the sparking plugs from the engine, taking care with unscreened plugs not to damage the mica-insulated top sleeve.

Measure each gap of all plugs. The increase since the last inspection should not exceed 0·002 in. per ten engine hours.

Test each plug for gas leakage as described later.

In the case of unscreened plugs, examine each one for damage to "top sleeve," and, in the case of integrally screened plugs, inspect the mica lining of the screen to ensure that it is not flaking or is otherwise damaged.

Dismantling the Plug

The plug should now be dismantled. This operation should be undertaken by holding the plug body in a vice block,

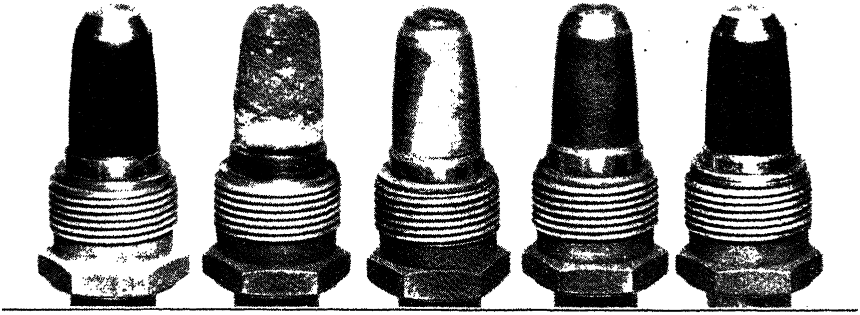


Fig. 2.—SHOWING HOW A USED PLUG CAN BE SERVICED SO THAT ITS CONDITION IS AS GOOD AS NEW

A, new plug with highly polished mica insulation; B, condition in which plug may be found after several hours' operation; C, condition of plug after lead deposits have been removed with a coarse emery and showing score marks on mica; D, the mica after polishing with a fine emery which has eliminated the scoring of the mica surface; E, illustrating the finish which can be obtained by servicing as described in this article.

which in turn is held in a vice, and, using a double-ended ring spanner, unscrew the gland nut.

Take care, when withdrawing the insulated central electrode, not to knock the mica insulation against any sharp edge within the plug body.

It should be noted that in both types of plugs the insulated central electrode is integral with the gland nut, and no attempt should be made to separate them.

The Insulated Central Electrodes

Examine the lower mica insulation for "pinholes."

The insulated central electrode should be set up in a polishing head capable of rotating at a speed of 2,500–3,000 r.p.m. Any hard deposit of lead is to be removed with Durex, Grade 150, John Oakey, Grade 1, or equivalent emery cloth, backed by a slip of wood (about ¼ in. thick by ¾ in. wide) until the surface of the mica is reached. It is very important that this operation, with what is a rather coarse abrasive, be limited to the removal of the deposit only, and that the diameter and shape of the mica insulation are not reduced or altered.

Scratches and imperfections on the surface of the mica, which will have resulted from the previous operation, should be removed by polishing with grade No. 0 emery.

The flat head of the central electrode should be cleaned with Durex, Grade 150, John Oakey, Grade 1, or equivalent emery cloth, to remove erosion indentations resulting from sparking. If these indentations are too deep, the " head " may be faced off in a lathe or grinding machine, until $\frac{12}{1000}$ in. (0·012 in.) is removed.

A special gauge, which is described later, should be used to check this operation.

The insulation and electrode head should now be polished with crocus and rouge powder.

Now repolish with a clean, dry, soft rag to remove any polishing material and to bring the surface of the mica to a high polish, in which condition it affords the greatest resistance to the deposit of lead.

The next operation is to remove the centre from the polishing head, and re-examine lower insulation for " pinholes " and particularly for the condition of the mica washers next to the head of the central electrode, for, if these show signs of burning on their edges, the plug should be discarded.

In the case of standard unscreened types, clean the " top sleeve " of mica washers with a soft rag dipped in petrol.

Test insulated central electrode for flashover voltage by means of a fixture in which the centre rests on two contacts—one to the gland nut and one to the terminal end with a calibrated ball gap in parallel. High-tension current is then applied from a spark coil and the " centre " should withstand an applied voltage of not less than 12,000 volts for a period of 10 seconds without any sign of sparking, either over or through the mica insulation.

The Body of the Plug

Remove the internal washer on which the gland nut of the insulated central electrode seats.

Clean inside of the body either with a scraper, a wire brush (used with care, not to damage the earth points), or with a reamer formed to the internal shape of the body.

Carefully remove carbon, oily deposits, etc., from around the lower end of body and from between the earth wires, but do not attempt to cleanse the wires themselves.

The cleaned body should be rinsed out in petrol and dried or submitted to an air blast. It must be ascertained that no foreign matter remains in the body or adheres to it.

Fit a new internal washer and check that it seats correctly.

Reassembly

Place body either in the vice block used for dismantling, or preferably in a special friction fixture which controls the applied pressure when reassembly is effected. Carefully insert the insulated central electrode and screw up finger tight, then finally tighten by means of the double-ended spanner.

Gap Setting

Invert assembled plug in the vice block, or friction fixture, and with wire gauge check gaps. If they are too wide, each wire must be pressed inwards ; if too close, prised outwards. Each wire should be bent so that it lies parallel to the surface of the flat-topped electrode head and the gap should be between 0·012–0·015 in.

A special K.L.G. gap-setting tool (see " Summary ") has been produced to effect this operation quickly and accurately. The use of this tool necessitates dismantling the plug, placing a shim of 0·012 in. thickness on the electrode head and reassembling. The setting tool is then screwed down on the body threads and a central plunger presses the wires down and parallel to the head. The plug must then be dismantled, the shim removed, and the plug reassembled. The gap settings should be checked for accuracy with a gauge.

Testing

The serviced plug should now be placed in a pressure test unit (see " Summary ")—a fixture to carry one, four, or six plugs, into which each plug is screwed into the underside of a chamber, which can be fed with compressed air from an air line or air bottle. The chamber must be provided with an inspection window opposite the inner end of the plug. Pressure at 100 lb. per square inch is applied, and, whilst current from a hand-starter type of magneto is supplied to the plug terminal, regular sparking should be observed for 20 seconds.

Whilst the plug is still in this unit with the air pressure maintained, it should be submerged in a glass of Sozol, so that the level of the liquid is over the gland nut. In the case of the " R " type integrally screened plug, a cork carrying a small tube through its centre should be inserted into the top of the screen.

A leak, if there should be one, is revealed by bubbles which will rise to the surface of the Sozol. A total leakage of 1 c.c. per minute is permissible, and in the absence of apparatus to measure this, it is roughly calculated that small individual bubbles, each about the size of a small shot, rising at the rate of one in 2 seconds, represent a leak which is within the limit, but that larger bubbles forming at this rate, or bubbles of the same size forming with greater frequency, are outside the limit.

It is not essential that plugs should be absolutely gastight, as the British Air Ministry specification allows a maximum permissible leakage of 1 c.c. per minute, but any leak is undesirable and plugs with excessive leakage must be discarded. No leakage is permissible from around the gland nut and, if found, is probably due to a faulty or incorrectly seating internal washer, or to the plug being improperly assembled.

A new external hollow copper washer should be fitted over the threads of the body.

In the event of serviced plugs not being racked in a proper fitting which

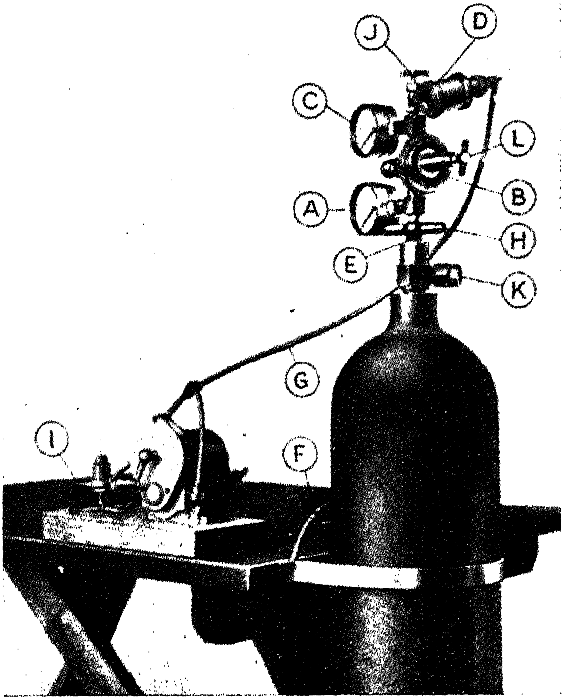


Fig. 3.—Service type test unit
With compressed air supplied by an air bottle.

will carry them safely and securely from any possible damage before refitting to an engine, each plug should be fitted with a protector cap over the body thread. This protects the lower threads and the earth wires, and prevents the ingress of dust and dirt into the mouth of the plug.

The method of pressure testing recommended in the above paragraphs enables the plug to be thoroughly tested for sparking under pressure and also for gas leakage.

Alternatively, the K.L.G. Service Type or K.L.G. Foot-pump Type test units may be used, but the Service-type unit is only designed to test the plug for sparking regularly under pressure and it is not practicable to test for gas leakage. The Foot-pump Type unit does, however, enable the gas leakage test to be applied. Descriptions of both these test units follow.

Summary

All operators should be fully familiar with the appearance of the inner insulation in a new and unused plug and realise that a reconditioned plug must approach very nearly to this standard.

To clean a used plug superficially, and perhaps leave a heavy deposit of lead and carbon products on the surface of the insulation, is worse than useless, as it may well lead to that plug being given a further period of service when its insulation is on the point of becoming short-circuited.

The illustration (Fig. 2) showing the internal mica insulation in varying conditions should be carefully studied.

In order to enable the foregoing testing and reconditioning operations to be carried out efficiently, it is recommended that the following equipment should be used :

(1) Vice block, with hexagonal hole to suit body hexagon of sparking plug.

(2) Double-ended spanner to suit gland nut of sparking plug.

(3) Friction-controlled fixture for reassembling.

(4) Electric polishing head, with suitable collets.

(5) Pressure test unit.

(6) Flashover fixture, with calibrated ball gap and coil and accumulator.

(7) Formed reamer for cleaning out bodies.

(8) Gap-setting tool with " shim."

(9) Gauge for faced-off electrode heads.

(10) Gauge for gap setting, type " B."

(11) Supply of suitable emery cloth and polishing material.

(12) K.L.G. Service Type test unit.

(13) K.L.G. Foot-pump Type test unit.

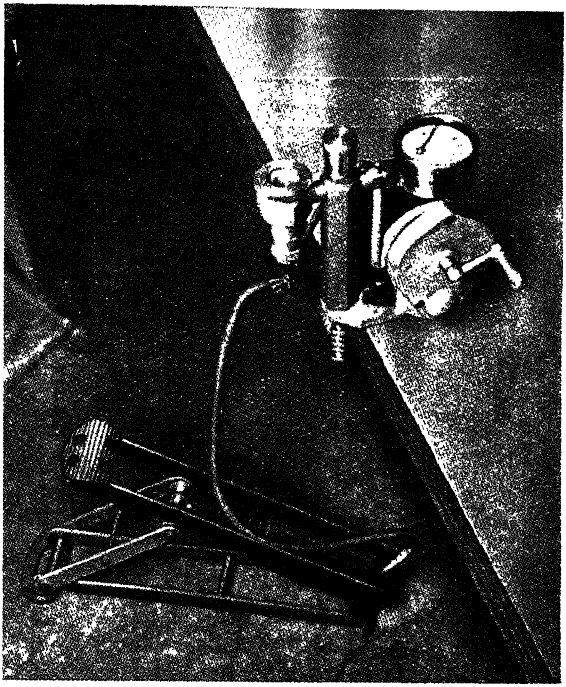


Fig. 4.—FOOT-PUMP TEST UNIT
With compressed air supplied by a foot pump.

Testing Apparatus—Service Type

K.L.G. Service Type test unit (Fig. 3) is intended for use with an air bottle. It comprises an air-pressure atmospheres gauge (A), a reducing valve (B), a gauge for pounds per square inch pressure (C), and a viewing chamber (D), all mounted in one unit, together with a hand-starter type magneto.

This unit provides a means of testing plugs in open air and also under a constant pressure of 100 lb. per square inch.

Testing Apparatus—Foot-pump Type

This test unit (Fig. 4) is basically an adaption of the Service type, and serves the same purpose. It is more compact, and is of a portable nature, as compressed air is supplied by means of a foot pump.

RECOMMENDED SPARKING PLUGS FOR BRITISH AERO ENGINES

Make of Engine	*K.L.G. Type Plug*
Armstrong Siddeley	
Cheetah IIA	V.7/3, V.7/4
Cheetah V	V.7/3, V.7/4
Cheetah VA	V.14/1-B, V.14/4-B, W.14-B
Cheetah VI	V.7/3, V.7/4
Cheetah IX	V.14/1-B, V.14/4-B, W.14-B
Cheetah X	V.14/1-B, V.14/4-B, W.14-B
Civet	V.7/3, V.7/4, W.1/1
Genet	V.7/3, V.7/4
Genet Major	V.7/3, V.7/4
Genet Major IA	V.7/3, V.7/4
Genet Major Mk. III	V.14/1, V.14/4, W.14
Genet Major Mk. IV	V.14/1, V.14/4, W.14
Jaguar IVc	V.7/3, V.7/4
Jaguar VIA	V.7/3, V.7/4, W.1/1
Jaguar VIc	V.7/3, V.7/4
Lynx IV	V.7/3, V.7/4, W.1/1
Lynx IVc	V.7/3, V.7/4
Leopard	V.7/3, V.7/4, W.1/1
Leopard IIIA	V.7/3, V.7/4, W.1/1
Mongoose IIIc	V.7/3, V.7/4
Panther IIA, VI, IVc, VII	V.7/3, V.7/4, W.1/1
Panther IXA	V.14/1-B, V.14/4-B
Panther X	V.14/1-B, V.14/4-B, W.14-B
Serval I	V.7/3, V.7/4, W.1/1
Serval III, IV, V	V.7/3, V.7/4
Tiger IV	V.7/3, V.7/4, W.1/1
Tiger VI, VIII, IX	V.14/4-B
Bristol	
Jupiter IV	V.6
Jupiter VI-A, VI-AM, VI-AL, VII, VIIA, VIII, IX, X, XI.	V.4
Jupiter " F " Series	V.11-B
Jupiter VIIIF and FA, X-FAM, X-FBM, XI-F	V.11-B, W.1/1-B
Mercury IV-S2	V.11-B
Mercury VI-S, VI-SP, VII, VIII, IX, XI, XII	V.7/4-B or R-V.7/4
Pegasus I-M2, I-M3, I-L2, I-L3	V.11-B
Pegasus II-B, II-M, III, IV, VI, VIII, X, Xc, XI, XII, XVII, XVIII, XIX, XX, XXII, XXIII	V.7/4-B or R-V.7/4
British Salmson	
A.D.9 Junior	V.12, V.12/1
A.D.9R and Series II	V.12, V.12/1
A.D.9R—Series III	V.12/2
Cirrus	
Cirrus II and III	V.7/3
Cirrus Hermes II and IIB	V.7/3
Cirrus Hermes IV and IVA	V.12
Cirrus Major Mk. I	V.12/1
Cirrus Minor " 90 "	V.14/1, V.14/4
Cirrus Major " 150 "	V.14/4

RECOMMENDED SPARKING PLUGS FOR BRITISH AERO ENGINES—*continued*

Make of Engine	*K.L.G. Type Plug*
Gipsy	
Gipsy I, II, III	V.12, V.12/2
Gipsy Major—Series I	V.12, V.12/2, R-V.12/4
Gipsy VI—Series I	V.12, V.12/2, R-V.12/4
Gipsy VI—" R "	V.12/1 (bar earth)
Gipsy Major—Series II	V.14/1, R-V.14/1
Gipsy VI—Series II	V.14/1, R-V.14/1
Gipsy Twelve	R-V.14/4
Napier	
Lion V, XIA, XV	V.7/2, V.7/4
Pobjoy	
" R "	V.12/1
Cataract I, II, and III	V.12/1
Niagara I and II	V.12/1
Niagara III, IV, V	V.14/1
Rolls-Royce	
Kestrel " A," " B," and " S ".	V.7/3, V.7/4
Kestrel, other Series	V.7/3-B, V.7/4-B
Wolseley	
Aquarius	V.7/2
Avis	V.7/2
Scorpio Mk. I	V.7/2
Scorpio Mk. II	V.14/1

General Notes on Sparking-plug Maintenance

(*a*) All material used for cleaning and polishing the mica centres must be free from particles of grit or metal. It is advisable to keep cleaning material solely for this special purpose.

(*b*) Mica insulation should on no account be filed or machined to remove any surface defects. Such operations would reduce the diameter of the mica washers and would probably move them, causing a breakdown of the insulation.

(*c*) Central electrodes in which the nickel tip is loose must be discarded ; no attempt should be made to recondition them. This type of defect indicates that the sparking plug has been overheated.

(*d*) If the insulation of the central electrode shows signs of being scorched or the surface has deteriorated, the central electrode should be rejected. This defect takes the form of discoloured patches on the mica and indicates that the sparking plug has been blowing. If a sparking plug with this defect is used, pre-ignition in the cylinder is possible, due to an excessive temperature being set up by the leakage of hot gases through the mica.

(*e*) The small nut at the top of the central electrode which grips the mica washers must not be tightened, as this may cause the mica wrapping inside the sparking plug to turn and so ruin the insulation.

(*f*) If the central electrode shows excessive reduction in diameter due to the scaling of the steel or due to continual reconditioning, it should be discarded.

(*g*) The mica insulation of reconditioned sparking plugs should, as a general rule, take a high polish, be of a uniform shade of colour, and free from defects.

(*h*) The gap between the sparking-plug points must not be adjusted by bending the central electrode under any circumstances ; the earth electrode should be bent for this purpose.

(*i*) If the earth electrode in the body is loose, the body must be rejected.

(*k*) The central electrode of some types of sparking plugs has an eccentric tip, and all adjustments for gap must be made by rotating this electrode.

DE-ICING EQUIPMENT

THE formation of ice on the wings, tail surfaces, control surfaces, and other parts of an aeroplane constitutes a very serious danger, and most aeroplanes are now fitted with suitable equipment to prevent the formation of ice.

There are three methods in general use :

(1) The Dunlop de-icing equipment, known as the fluid de-icer.
(2) The Goodrich equipment, which is a mechanical system.
(3) De-icing paste.

The Dunlop De-icer

In the Dunlop system the principle is to maintain on those surfaces where ice is most likely to form a layer of fluid which will prevent the formation of ice by lowering the freezing-point of water. If ice should form on the surface, then the fluid exuding from below melts the ice with which it comes in contact, and thus forms a liquid boundary layer which enables the remaining ice to be detached by the airstream.

It has been found that a mixture of ethylene-glycol achieves this purpose, and the mixture is led to the surfaces through a porous rubber fabric which is fixed to the surfaces. The system is shown diagrammatically in Fig. 1.

The mixture is forced through the perforations under pressure, the desired rate of delivery being suitably regulated and maintained. This method is employed for the protection of the leading edges of the main planes and control surfaces and airscrews.

The Goodrich System

In the case of the Goodrich system, which is marketed in this country by the British Tyre & Rubber Co., Ltd., compressed air is used to pulsate rubber tubes, covered with a rubber "overshoe" placed along the leading edge, the deformations on which tend to break up the ice, which is then blown away by the slipsteam.

It consists essentially of a rubber overshoe, attached to the leading edge of each aerofoil of the aeroplane, containing tubes capable of inflation by means of air pressure. The surface of the overshoe is formed of a thin sheet of vulcanised rubber, which has been treated, during manufacture, with a certain special mixture of oils. Thus the rubber, which in itself possesses a low adhesion tension towards water, is permanently lubricated by the oils, and is, accordingly, still less liable to collect moisture.

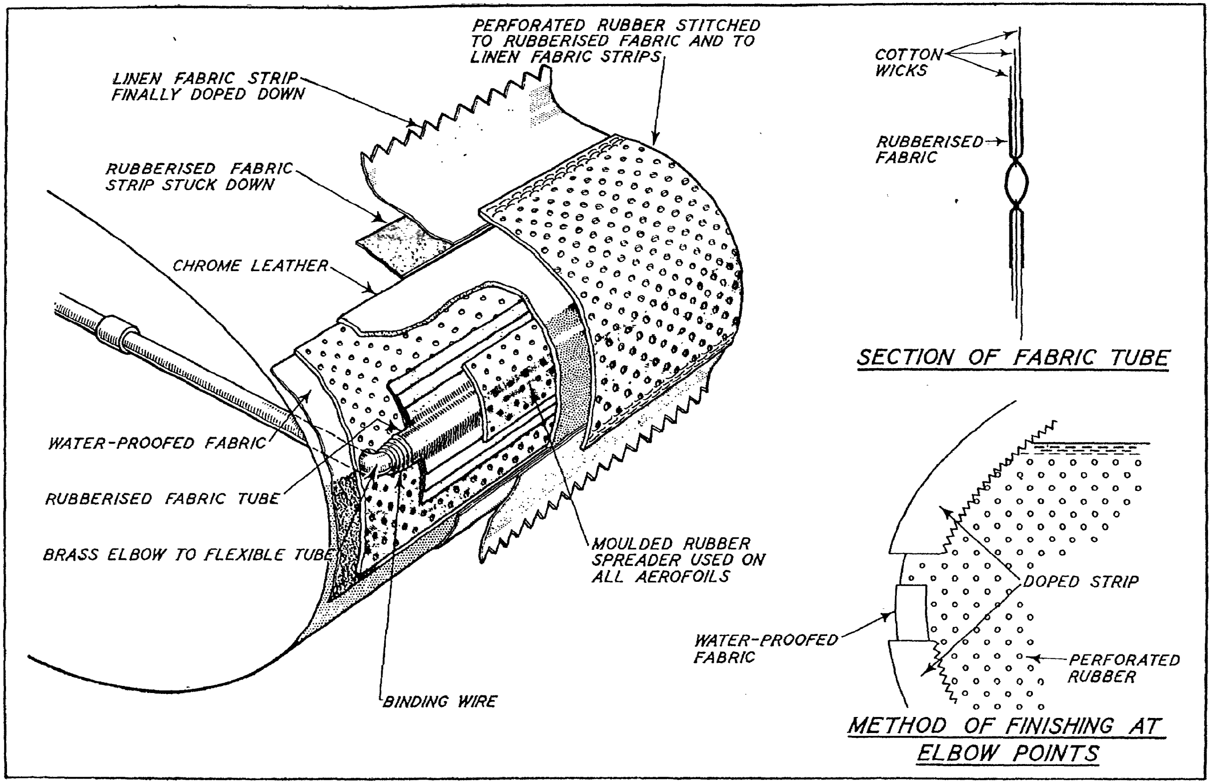

PERFORATED RUBBER STITCHED TO RUBBERISED FABRIC AND TO LINEN FABRIC STRIPS
LINEN FABRIC STRIP FINALLY DOPED DOWN
RUBBERISED FABRIC STRIP STUCK DOWN
CHROME LEATHER
WATER-PROOFED FABRIC
RUBBERISED FABRIC TUBE
BRASS ELBOW TO FLEXIBLE TUBE
BINDING WIRE
MOULDED RUBBER SPREADER USED ON ALL AEROFOILS
COTTON WICKS
RUBBERISED FABRIC
SECTION OF FABRIC TUBE
DOPED STRIP
WATER-PROOFED FABRIC
PERFORATED RUBBER
METHOD OF FINISHING AT ELBOW POINTS

Fig. 1.—TYPICAL EXAMPLE OF DUNLOP DE-ICING EQUIPMENT FOR WING SURFACES

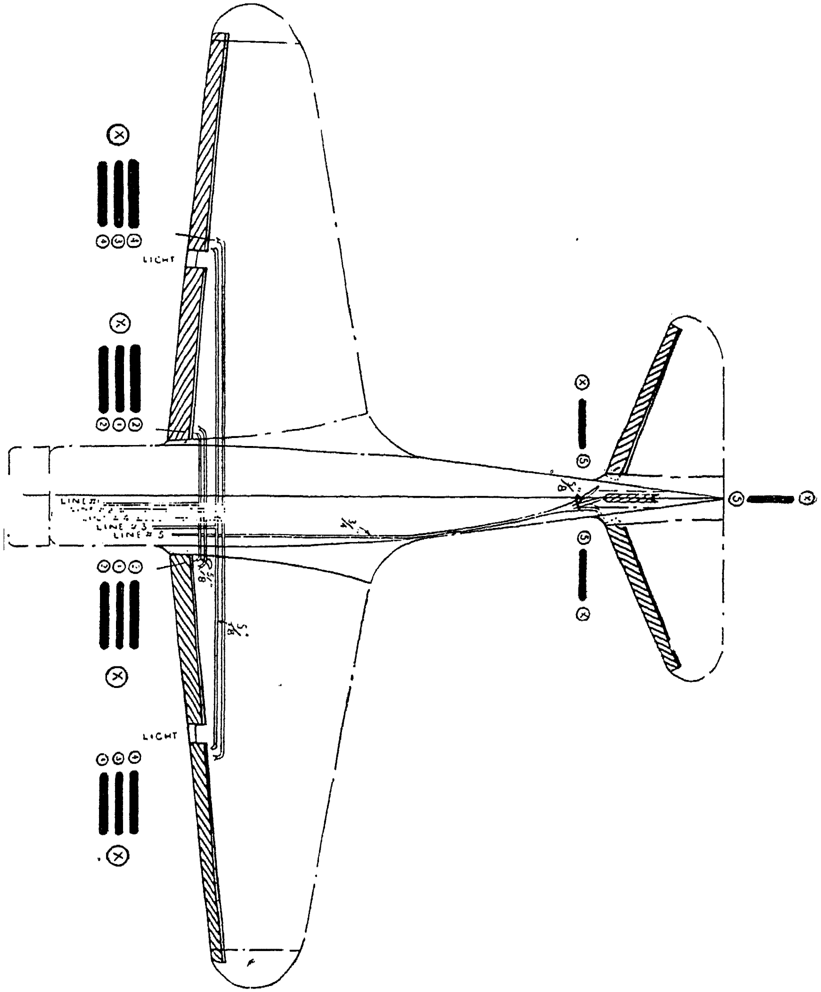


Fig. 2.—TYPICAL DE-ICER DISTRIBUTION INSTALLATION FOR SINGLE-ENGINE AEROPLANE
(*British Tyre & Rubber Co., Ltd.*)
X = Tube layout and connections (frontal view).

There are three major parts to this de-icer, apart from the mechanical equipment used in its operation. They are :

(1) The inflatable tube sections positioned along the leading edge of the aerofoil.

(2) Elastic sections of reinforced rubber on either side of the tube section ; and

(3) Fabric-covered steel reinforcing strips used for attaching the

assembly at its outer edges. It has been found that no appreciable change in the performance of the aeroplane is caused.

The inflatable unit is usually composed of three longitudinal tubes.

These are built into the main body of the de-icer, inserted during construction between the plies of rubber. When installed on the aeroplane the middle tube is centred on the leading edge, with the other tubes above and below it respectively. These tubes are inflated by compressed air, the centre one being inflated by itself alternately with the outer ones, which are inflated together. The inflating and deflating of alternate tube groups gives a rocking action which cracks the ice and lifts it so that the airstream can get beneath it and sweep it clear of the aeroplane.

On the control surfaces and radio mast (that is, the fixed aerial), owing to the smaller aerofoil, only two tubes are used.

Operation of the De-icer

The controls for the operation of the de-icer are located in the cockpit so that the pilot can operate them. When he finds that he is entering an ice-forming layer he sets the control, and the pulsating action of the equipment starts and acts continuously until turned off.

A single pump provides the necessary air pressure. The intake side of the pump supplies adequate suction to operate a complete set of navigation instruments, such as a turn and bank indicator, directional gyro and artificial horizon, thereby eliminating the use of venturi tubes and surmounting the ice problem in so far as they are concerned.

Fig. 6 shows the layout of the pneumatic control system.

CARE AND MAINTENANCE OF GOODRICH DE-ICER

The following notes on the care and maintenance of the Goodrich de-icer equipment (wing and horizontal stabiliser) apply in particular to the Lockheed " 14 " and " 18." We are indebted to the Lockheed Aircraft Corporation for permission to publish these details.

Operation and Control

Air under pressure is derived from exhaust sides of vacuum pumps. This air must be absolutely free from oil, hence the use of oil separators. The air, after leaving the separators, is led to a distributor valve, which meters the flow to various tubes.

Control consists simply of an Ahrens push-pull control, with which a single motion is used to both open valve and start valve-rotating motor or vice versa.

Maintenance

(*a*) Ground Check

In order to check the functioning of the de-icer system without running the aeroplane's engines, some means of supplying approximate

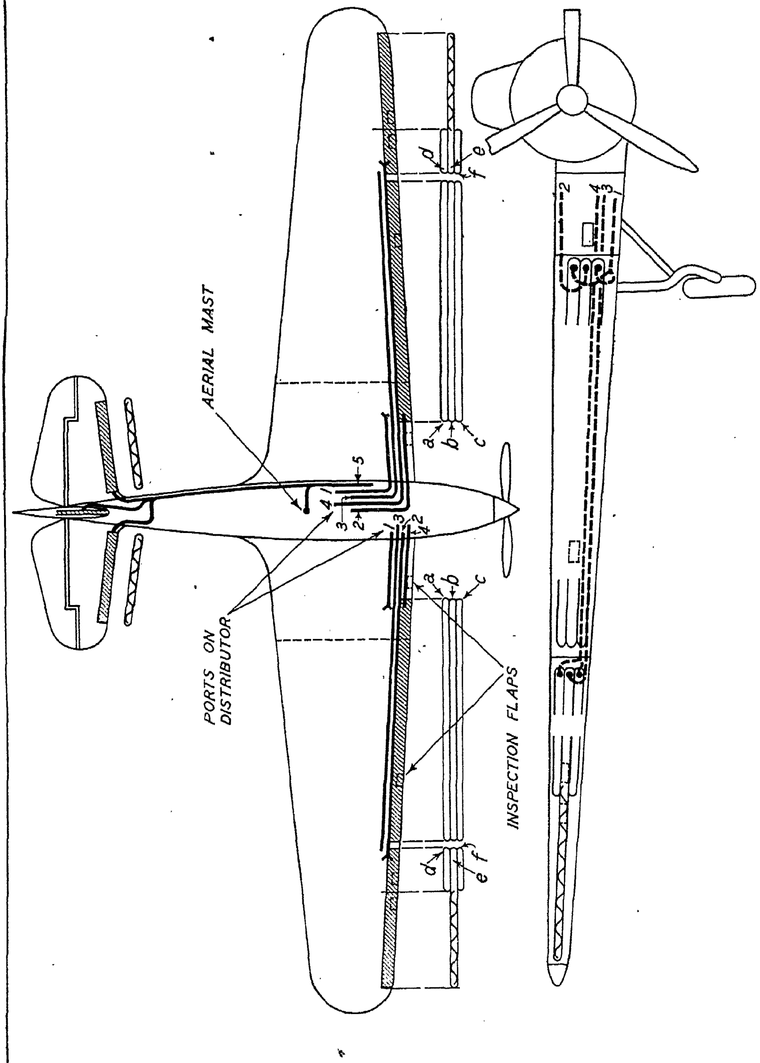
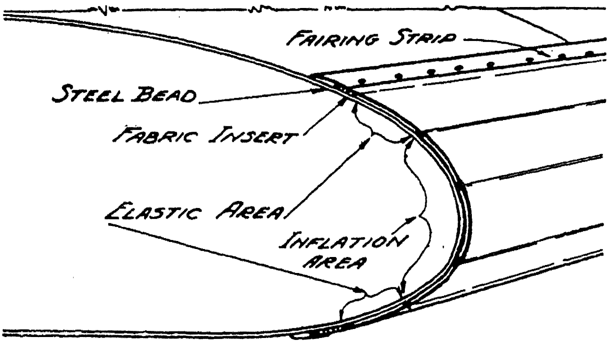
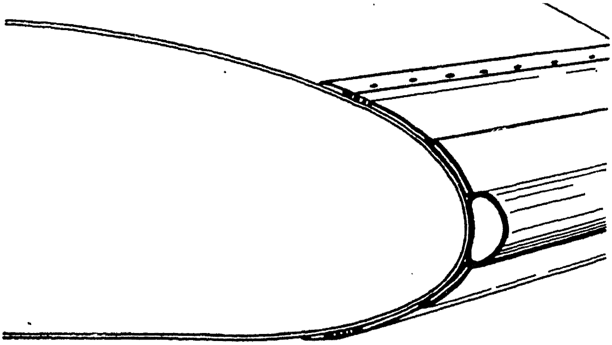


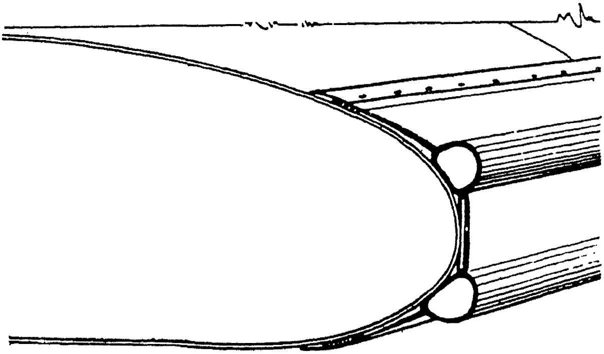
FIG. 3.—LAYOUT OF CONNECTIONS FOR GOODRICH WING SURFACE DE-ICING EQUIPMENT



De-icers not functioning.



De-icers functioning, centre tube inflated, outer tubes deflated.



De-icers functioning, centre tube deflated, outer tubes inflated.

Fig. 4.—DIAGRAMS SHOWING OPERATION OF DE-ICERS ON WINGS
(*British Tyre & Rubber Co., Ltd.*)

total free air capacity of system at a pressure of not over 10 lb. per square inch (0·703 Kg./sq. cm.) should be devised.

This air supply may be attached by disconnecting pipe from exhaust side of one of vacuum pumps and inserting outside supply into this pipe to be carried to distributor valve.

The control should then be turned on. The de-icer pressure gauge should be watched, and if excessive pressure is built up, the system should be shut off immediately.

Relief Valve

The relief valve in the back of the oil separator behind main beam is set to open at 7 lb. (0·492 Kg./sq. cm.) pressure, but it cannot be relied upon to handle large volumes of air. It is therefore advisable to begin test with test rig set to deliver only a small volume of air and gradually work up to a required amount mentioned above.

Loss of Pressure

If pressure does not build up properly in de-icer system, tap check valves in pipes from pumps to make sure they are seated properly. Check for loose connections or any other condition which would cause loss of pressure.

The pressure gauge will fluctuate with various phases of inflation cycle, but it should indicate not less than 6 lb. (0·422 Kg./sq. cm.) or more than 7 lb. (0·492 Kg./sq. cm.), as each group of tubes is fully inflated. A complete cycle takes place approximately every 40 seconds, hence, if a five-port distributor valve is used, a peak should be noted every 8 seconds.

Adjusting Pressure

The de-icer operating pressure may be increased or decreased respectively with a clockwise or counter-clockwise adjustment of relief-valve adjusting screw. However, no adjustment should be made until all other possibilities of pressure variation have been eliminated.

If de-icer action is sluggish, it is advisable to check pipes leading to sluggish part for any restriction or congealed oil. All air pipes from distributor valve to rubber parts should be kept absolutely clean and unrestricted at all times.

(*b*) Repairs to De-icer Shoes

" De-icer " shoes should be inspected periodically for punctures. Any punctures found should be patched immediately, using Goodrich de-icer patches. These patches are made in various sizes, and the method of application is the same as any cold-process inner-tube patch. It is recommended that shields be cut from shim stock, and be used in cleaning, buffing, and cementing the area to be patched. In this way, glazed sur-

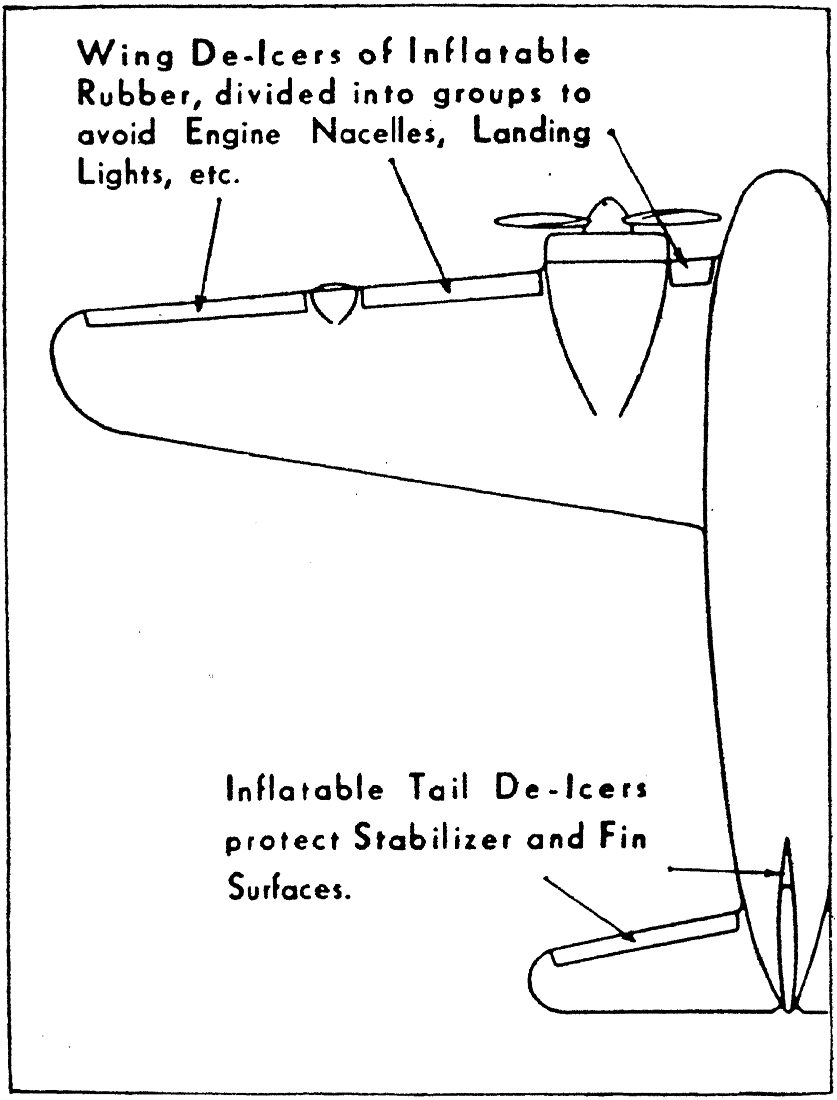

Wing De-Icers of Inflatable Rubber, divided into groups to avoid Engine Nacelles, Landing Lights, etc.
Inflatable Tail De-Icers protect Stabilizer and Fin Surfaces.

Fig. 5.—DIAGRAM SHOWING LOCATION OF DE-ICERS ON MAIN PLANES AND TAIL PLANES
(*British Tyre & Rubber Co., Ltd.*)

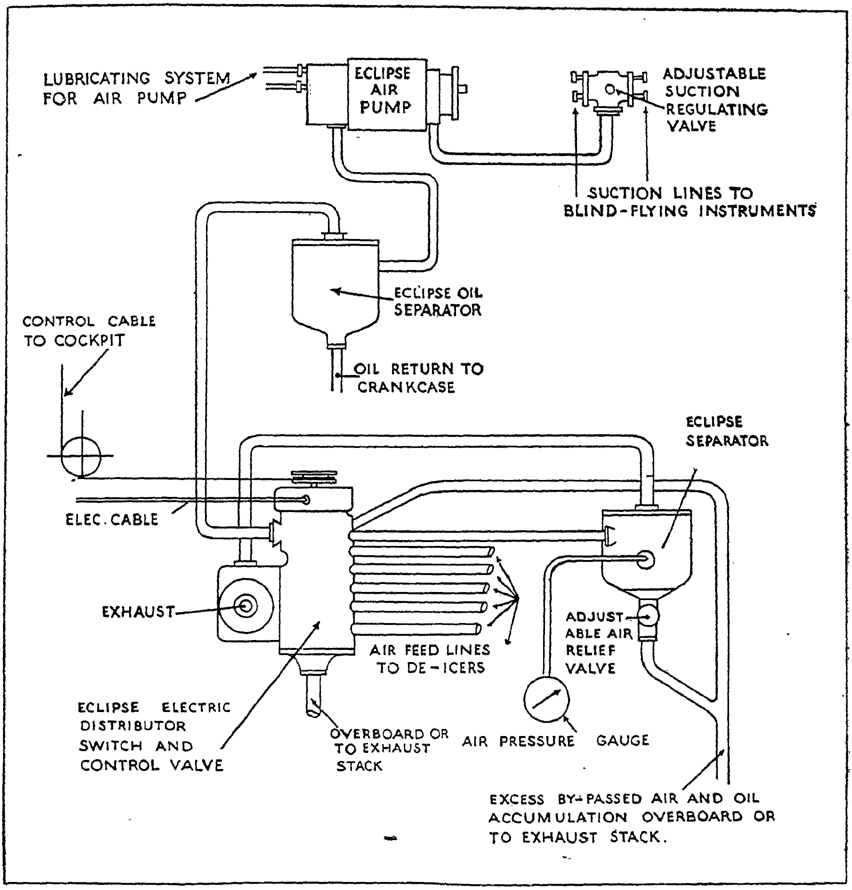

LUBRICATING SYSTEM FOR AIR PUMP
ECLIPSE AIR PUMP
ADJUSTABLE SUCTION REGULATING VALVE
SUCTION LINES TO BLIND-FLYING INSTRUMENTS
ECLIPSE OIL SEPARATOR
CONTROL CABLE TO COCKPIT
OIL RETURN TO CRANKCASE
ECLIPSE SEPARATOR
ELEC. CABLE
EXHAUST
ADJUSTABLE AIR RELIEF VALVE
AIR FEED LINES TO DE-ICERS
ECLIPSE ELECTRIC DISTRIBUTOR SWITCH AND CONTROL VALVE
OVERBOARD OR TO EXHAUST STACK
AIR PRESSURE GAUGE
EXCESS BY-PASSED AIR AND OIL ACCUMULATION OVERBOARD OR TO EXHAUST STACK.

Fig. 6.—LAYOUT OF PNEUMATIC CONTROL SYSTEM WITH VERTICALLY OPERATED DISTRIBUTOR
(*British Tyre & Rubber Co., Ltd.*)

face of the de-icer is removed only from that area to which the patch will be applied.

(*c*) Cleaning De-icers

Engine oil should be removed from the surfaces of the de-icers as soon as the aeroplane comes in from a run. Petrol may be used to wash oil from shoes. The solvent should not be allowed to dry on shoes, but should immediately be wiped off with a clean, dry rag.

De-icers may be washed with a mild soap and water as part of regular cleaning of aeroplane, although it is recommended that de-icers be washed only when they need it. The polished dark-brown or

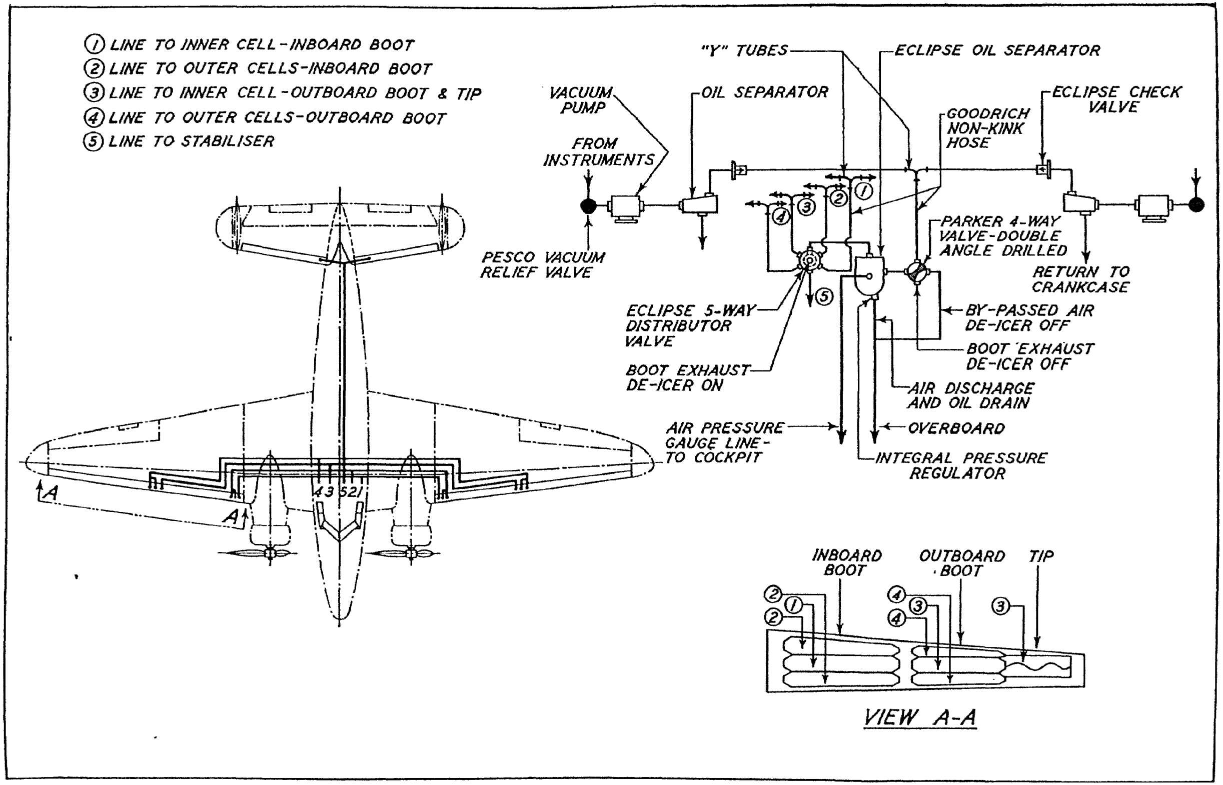

① LINE TO INNER CELL-INBOARD BOOT
② LINE TO OUTER CELLS-INBOARD BOOT
③ LINE TO INNER CELL-OUTBOARD BOOT & TIP
④ LINE TO OUTER CELLS-OUTBOARD BOOT
⑤ LINE TO STABILISER
"Y" TUBES
ECLIPSE OIL SEPARATOR
VACUUM PUMP
OIL SEPARATOR
ECLIPSE CHECK VALVE
GOODRICH NON-KINK HOSE
FROM INSTRUMENTS
PESCO VACUUM RELIEF VALVE
PARKER 4-WAY VALVE-DOUBLE ANGLE DRILLED
RETURN TO CRANKCASE
ECLIPSE 5-WAY DISTRIBUTOR VALVE
BY-PASSED AIR DE-ICER OFF
BOOT EXHAUST DE-ICER OFF
BOOT EXHAUST DE-ICER ON
AIR DISCHARGE AND OIL DRAIN
AIR PRESSURE GAUGE LINE-TO COCKPIT
OVERBOARD
INTEGRAL PRESSURE REGULATOR
① ② ③ ④ ⑤
A
A
4 3 5 2 1
INBOARD BOOT
OUTBOARD BOOT
TIP
② ① ② ④ ③ ④ ③
VIEW A-A

Fig. 7.—De-icer wing and stabiliser layout for Lockheed "14" and "18" black surface which develops on rubber parts should be removed only when necessary to apply patches.

(*d*) **General**

De-icers must of necessity be built of a soft, flexible rubber stock in order to perform their function of flexing and stretching under relatively low operating pressures. This means that de-icers are not particularly tough, and care must be used in dragging petrol hose, etc., over them. It is recommended that ladders or platforms, which must rest against the de-icers, be equipped with sponge rubber pads.

De-icers should be removed in the spring as soon as conditions warrant. It is a good procedure to inspect and patch de-icers upon their removal from the aeroplane. They should then be wrapped in heavy paper and placed in cold, dark storage.

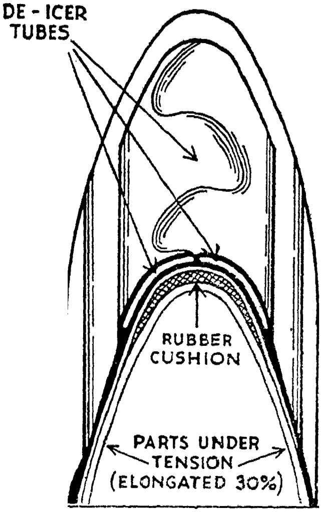


Fig. 8.—DE-ICER EQUIPMENT FOR TAIL PLANES AND FINS. (*British Tyre & Rubber Co., Ltd.*)

At same time, remove distributor valve and oil separator, dismantle and clean thoroughly. If any signs of wear are apparent, replace the affected parts.

Caution.—When distributor valve is reassembled, DO NOT OIL the valve rotor. Action of this part is so slow that lubrication is unnecessary. Oil applied at this point would find its way to rubber tubes and cause rapid deterioration.

Install holeless rubber grommets in apertures, in the wing surface, left by the removal of rubber de-icer shoes. Also remove rubber hose and, inside rear portion of fuselage, cap tubes for stabiliser de-icer units.

De-icing Paste

The principle of a de-icing paste is that a substance shall be applied to the components likely to be affected by ice accretion which will prevent ice forming. Here again the basis of the paste is a material like ethylene glycol, which lowers the freezing-point of water, or if ice forms, tends to produce a liquid boundary layer between the surface and the ice, which facilitates removal of the ice by the airstream.

Api G P.

The material is applied by smearing it all over the necessary parts, and it is obvious of course that it can only be considered as a temporary expedient, as only a limited quantity of the active material can be applied to the surface, and loss of this material must proceed as the action takes place.

AIRSCREW PROTECTION

In the case of airscrews, ice formation is most likely to occur on the boss and inner portions of the blades, the outer portion being maintained at a temperature considerably higher than that of the air, owing to heat generated in overcoming viscous drag.

Not only does it reduce the efficiency of the airscrew, but it may also cause loss of balance, which may make it necessary to throttle down the engine when its power is most needed.

The B.T.R. method of protection is for a de-icing solution to be fed over the surfaces of the airscrew blades.

The equipment used for obtaining this result consists essentially of a slinger ring mounted on the back of the airscrew hub, and a means of supplying the de-icing solution to the slinger.

The slinger ring shown in Fig. 10 is a typical ring for a three-blade airscrew. The method of mounting to the hub must be modified to suit various airscrew installations. The essential part is the location of the tubes spilling the solution upon the blades. These tubes are so placed that they run along the blades parallel to their centre lines and from points just below the respective leading edges, when the blades are in cruising-pitch position.

The de-icing solution is fed into the slinger ring through a tube mounted on the front of the motor case leading into the slinger. This tube is connected to a supply tank which, in many cases, can be so located that gravity alone will operate the feed. In other installations, air pressure from the exhaust side of the instrument pumps, together with a suitable relief valve, may be used. In still other cases it may be necessary to use a small electric pump to feed the solution to the slinger.

A three-blade airscrew should be supplied at the rate of approximately two quarts per hour, and on this basis a three-gallon tank of the solution was used for a two-engine aeroplane on test, giving a supply adequate for three hours' use of the airscrew de-icing equipment. A control valve to regulate the flow of the solution to the suggested rate is included in the installation.

It should be noted that every system of airscrew de-icing should include a spinner over the front of the airscrew hub. This is covered with a special rubber, which is kept saturated with B.T.R. de-icer oils to minimise the adhesion between the ice and the spinner, and to permit the ice to be thrown off by centrifugal force in small particles, while balance and general efficiency remain unaffected.

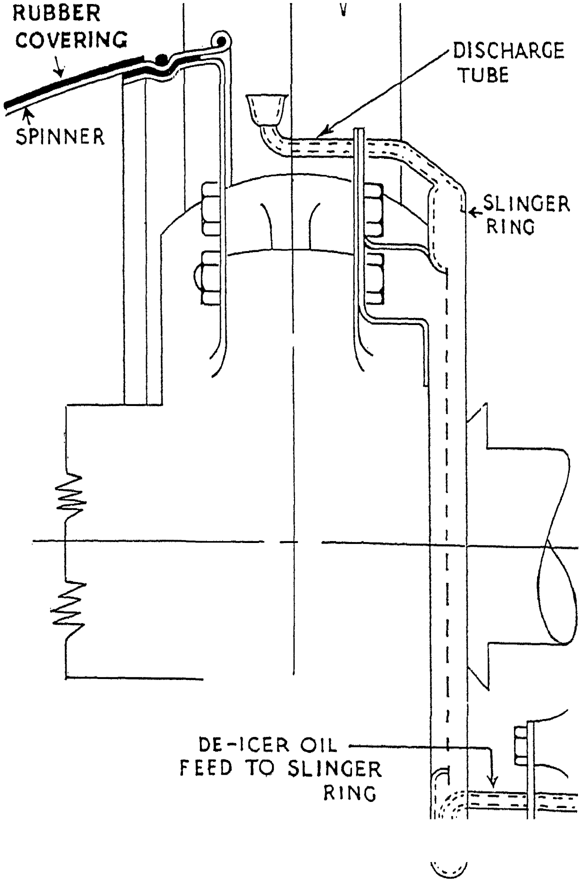


Fig. 10.—De-icer equipment for protection of airscrew (*British Tyre & Rubber Co., Ltd.*)

Control

In the case of the equipment fitted to the Lockheed "14" and "18," fluid is fed to slinger ring through tubing from an Eclipse air-screw de-icer pump. Pump is a dual-diaphragm, electrically driven mechanism. Base casting contains a reservoir of light oil used to lubricate pump. The diaphragms, when pumping de-icer fluid, also circulate this oil, making the pump a self-lubricating unit.

The driving motor speed and consequently rate of flow of fluid is governed by a rheostat in cockpit.

Maintenance

Maintenance consists chiefly of frequent inspection of following:

(1) All tubing to ensure tight fittings and continuity.

(2) Supply tank for leaks.

(3) Slinger ring and spinner for secure mounting.

(4) Slinger-ring outlet tubes, to be sure that no glycerine residue is restricting flow.

Care of Equipment when not in Use

(*a*) Remove rubber button from hole in skin under supply-tank drain.

(*b*) Remove drain plug and drain tank.

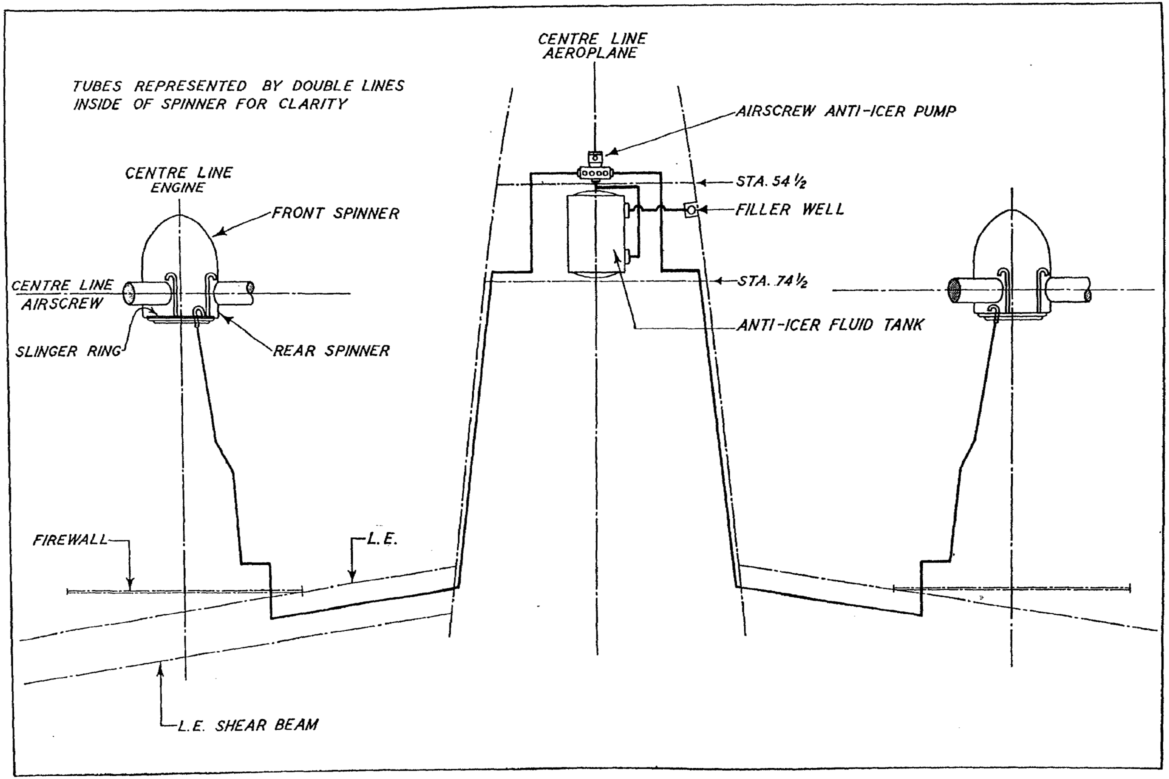


Fig. 11.—Layout of airscrew de-icer for Lockheed "14" and "18" (*c*) Replace drain plug.

(*d*) Inside nose baggage compartment fill tank with alcohol at filler tube in rear right corner of compartment.

(*e*) Remove spinner and slinger-ring assemblies from airscrews.

(*f*) Place containers to catch fluid from outlets at airscrews.

(*g*) Start system and allow to run until all alcohol has been run through. This will thoroughly clean system of all possible gummed glycerine and leave it free and clean for future operation.

Acknowledgments

We are indebted to the British Tyre & Rubber Co., Ltd., and the Lockheed Aircraft Corporation for providing some of the details given in this article.

PACKING, INSPECTION, AND MAINTENANCE OF PARACHUTES

THE general principle of the modern parachute is that of a self-contained unit operated at will by exerting a moderate pull on a rip-cord ring. It is obviously desirable that the occupant of an aeroplane leaving it in an emergency should be well clear of it before his parachute comes into action and the rip cord should therefore not be "pulled" until he has dropped sufficiently far to be clear. The parachute opens almost instantaneously, the small auxiliary parachute opening first and helping the main canopy to unfold.

Before dealing in detail with the packing of parachutes, the following brief notes on the operation of a parachute may be useful.

When the rip cord is pulled the sequence of events is as follows :

The pins are withdrawn from the cones and with the help of the stretched elastics the four flaps of the parachute pack cover fly open. Immediately the pressure is released, the auxiliary parachute springs out and opens, fills with air and in acting as an anchor assists the main canopy to get clear of the cover. As the tension on the rigging lines begins, they are pulled out of their retaining pockets in the pack cover until finally the lift webs to which they are attached are also drawn clear of the pack cover and upwards. The pack cover remains in the same position, it being fastened to the harness by press studs.

The parachute canopy opening out and filling with air begins to take up the load and the lift webs tighten upon the shoulders of the wearer through the fitting which connects the two lift webs on each shoulder. If at the time, as is often the case, the parachutist is on his back in relation to the earth below, the canopy brings him into a normal position again, seated comfortably in his harness. At first he is swinging a little from side to side, but this soon ceases and the steady gradual descent to earth begins.

As he gets nearer the ground the parachutist is able to control the direction of his drift by pulling down the edge of the parachute in the required direction. This is done by grasping the corresponding lift webs or rigging lines. By this means it is possible to avoid landing on obstructions such as trees or houses.

The rate of descent is approximately 16 ft. per second and the shock of landing is equivalent only to a jump from a 9-ft. wall. The landing is made as far as possible on the toes and with the knees flexed. Immediately he lands, the parachutist frees himself from the harness with the quick release device and gathers the canopy into a bundle to prevent it blowing away.

We will now describe in detail the packing of the Irvin and G.Q. parachutes.

The Packing Shed

The packing shed should be large enough to accommodate the 40 ft. by 4 ft. packing table with ample working space around it and high enough to permit parachutes to be suspended by their apices so that at least the canopy is clear of the floor. It would, of course, be preferable to hang the parachutes so that the rigging lines too are clear of the floor, but this is generally impracticable.

The Atmosphere in the Shed

During the drying and packing processes it is important that the correct air conditions should be maintained. The heating and ventilation of the shed must be arranged with this in view. The roof must be watertight, and the windows and ventilators so designed and situated that rain or moist air cannot blow directly upon the parachutes, particularly when they are hanging. The shed should also exclude dust. An entrance lobby with a second door forming an air lock will be helpful in maintaining the correct temperature and excluding dust.

The air in the shed should be kept dry and at a temperature between 55 and 65° F.; good ventilation is essential and care should be taken to protect parachutes from the direct heat of any heating apparatus except for short periods during the drying process. Precautions should be taken to minimise the risk of fire.

The Hanging of the Parachutes

If the height of the shed will not permit of the parachute being hung so that the rigging lines are clear of the floor, the lines and harness should be placed on smooth-topped tables arranged beneath the parachute. When hung, the canopy should be clear of all objects which might injure the fabric. The apex of the parachute is best attached to the suspension rope by means of a toggle or hook, and the rope should pass over two pulleys to ensure that it is led down well clear of the canopy. Care should be taken to prevent canopies touching each other during the drying process; to this end they should be hung so that they are at least 2 ft. 6 in. apart. Silk, exposed to direct sunlight for long periods, will deteriorate rapidly; such exposure must therefore be avoided.

Packing Tables

The packing table must support the whole of the parachute when laid out at full length, and for this reason it should be 40 ft. long. The width should be from 3 ft. 6 in. to 4 ft. The surface must be clean and perfectly

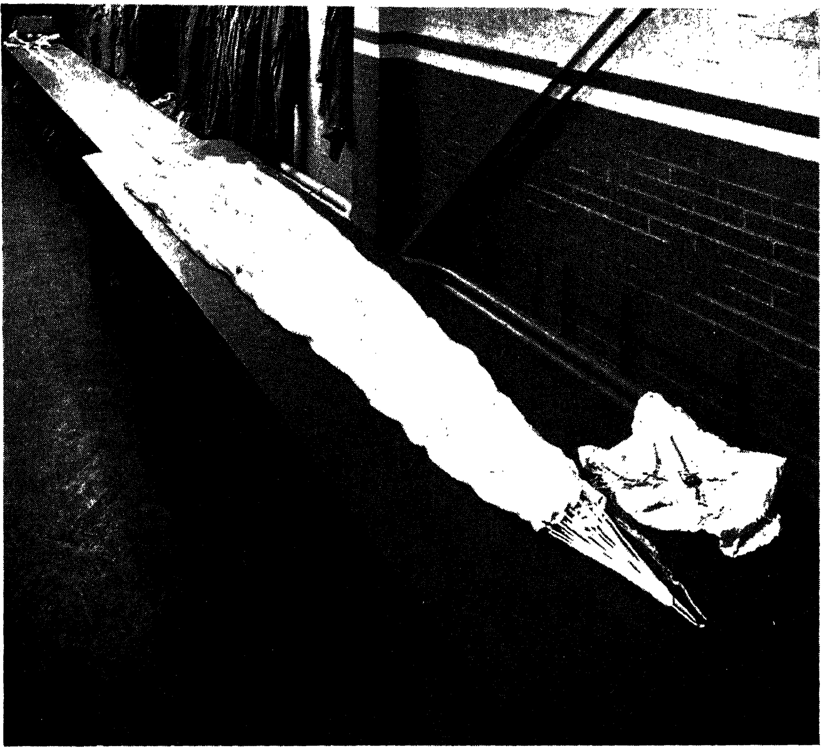


Fig. 1.—THE COMPLETE PARACHUTE LAID OUT FULL LENGTH ON THE PACKING TABLE

smooth. The best surface is afforded by unpolished linoleum, but a light canvas or fabric covering, coated with aeroplane dope (preferably of a dark colour), is satisfactory. Some means must be adopted for securing the rigging lines at the apex of the parachute to one end of the table : the best method is to employ a small wooden toggle attached by cord to a length of light webbing secured to the under side of the table, as shown in Fig. 1. A smooth hook, however, may also be satisfactory.

If an assistant is employed for the packing, a small narrow table at that end of the main table at which the canopy apex normally lies will enable the two packers to complete the final stages of the packing without having to stretch for long periods over the wider main table. If there is only one packer, however, this extra table is unnecessary, as the final packing may be done by one person equally well on the main table.

Arrangements for Storing Parachutes in the Packing Shed

Provision will usually have to be made in the packing shed for the storage of parachutes either when packed ready for use or when stowed

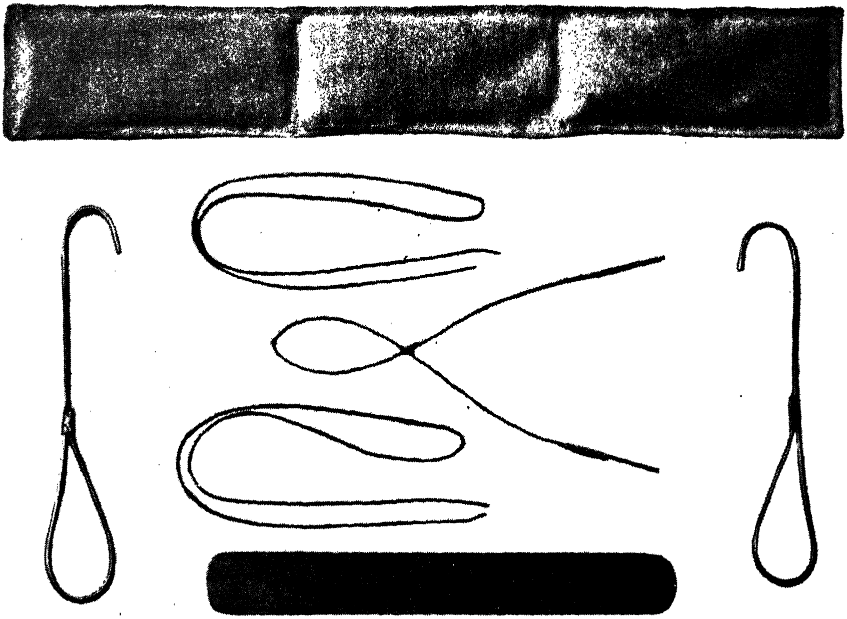


Fig. 2.—THE TOOLS REQUIRED FOR PACKING A PARACHUTE ARE SHOWN ABOVE

The shot bag is seen above, the rigging-line hooks at either side, the packing stick at the bottom, and the packing pins in the middle. The pieces of cord are shown above and below the packing pins.

unpacked in their travelling bags. The best method is to provide closed lockers or cupboards, a separate compartment approximately 20 in. wide by 15 in. high by 18 in. deep being provided for each parachute. Failing closed lockers, racks or shelves should be provided, divided if possible into separate compartments. In any event, parachutes must be given plenty of space, and they must on no account be stored one on top of another.

Parachutes must not be placed over any heating apparatus ; accumulations of dust must be prevented ; and lockers, cupboards, and racks must not be placed in contact with the walls of the building, as these may be damp. For the same reason parachutes must be kept well away from the floor and must not be allowed to touch the walls when stored on shelves. To ensure good ventilation, racks or shelves should be constructed of battens spaced slightly apart.

Parachute Spares, Records, and Notices

A locker, which should be subject to the same precautions against heat and damp as the parachute storage racks, should be set aside for the safeguarding of all spare parts such as packs, rip cords, pack-opening elastics, needles, thread, hooks and eyes, tools and the like. Receptacles should also be provided for log books and copies of repair and inspection instructions. Records should be kept to show when parachutes were last packed, when they are next due for inspection and packing and the dates of renewal of pack elastics, etc.

Packing Tools

The tools and equipment required for the packing operations are listed below :

Shot bags	6
Rigging-line hooks	2
Packing pins	1
Packing sticks	1
Packing cords	2

The articles are shown in Fig. 2 and their uses are as follows :

Shot bags are used as weights for holding down the panels of the silk canopy or parts of the harness during the early stage of packing. They weigh about 7 lb. each and measure 18 in. long by 3 in. wide. The bags are divided into three compartments of equal size by two seams across the width.

Rigging-line hooks are used to draw the rigging lines into their stowage pockets in the pack. Each consists of a length of $\frac{1}{4}$-in. diameter brass rod tapered and bent to a semicircle of $1\frac{5}{16}$ in. inside diameter at the end.

Packing pins are used to hold the pack closed temporarily over the folded parachute pending the insertion of the rip-cord pins. They consist of a $3\frac{1}{2}$-in. length of 14 S.W.G. hard steel wire attached to each end of a piece of 10-cwt. extra-flexible cable by copper wire binding and soldering. The free length of the pins is $1\frac{3}{4}$ in. and their ends are rounded to avoid damage to the pack-locking cones. A loop is made in the cable by soldering over copper wire binding.

The packing stick is used for smoothing down the main flaps of the pack when it is being closed and for tucking in the corner flaps, which have small pockets to receive the end of the stick. The stick is made of hardwood ; it measures 14 in. by $1\frac{1}{2}$ in., tapering in thickness from $\frac{3}{16}$ in. at one end to $\frac{1}{8}$ in. at the other. The ends are rounded and the edges smoothed down.

Packing cords, which are each about 3 ft. long, are used to draw the pack-cover flaps together and to pull the locking cones through the flap lug eyes. The silk cord used for the auxiliary parachute rigging lines is normally used for this purpose, but "Kanstrand" or 2-oz. kite cord is also suitable.

Care of Packing Tools

In order to avoid damage to any part of the parachute in the course of packing, every care must be taken to keep the tools in good condition.

Burrs and rough places on the metal parts must be smoothed down and any splinters on the packing stick removed, the rough parts being rubbed down with glass-paper. If a tool is dropped on a hard floor, it should be examined immediately for burrs or sharp edges. The tools may conveniently be kept on hooks on the wall of the packing shed, but precautions should be taken against damp.

PACKING OPERATIONS (IRVIN PARACHUTE)

General

The operations described in this article are based on the assumption that the packing is being done by one man. The directions and illustrations relate to the 24-ft. diameter canopy in a seat-type pack, it being assumed that the parachute has been returned in a tangled condition after use and has been aired for the necessary time in readiness for packing. The directions are, however, applicable in general to the other types of parachute.

The packer must realise that, so far as design and materials are concerned, every possible step has been taken to ensure that a properly packed parachute will open the instant the rip cord is pulled in the air : he must apply the same degree of thoroughness to the packing operations. At each stage he should ask himself whether he would trust his life to the way he has carried out the packing. Throughout the operations there must be no suspicion of careless, slipshod or hurried work, and the packer should be in a position to hand over the packed parachute with the complete conviction that this vitally important task has been done thoroughly and well.

Laying out the Parachute

Lay out the parachute at full length on the packing table and attach the main rigging lines at the apex of the canopy to the hook or toggle which is attached to the end of the table, making sure that the lines are divided equally by the hook. The canopy should not be attached by the auxiliary parachute extension piece, as this is not strong enough to withstand loads which may arise during packing.

Remove the back pad from the harness by unfastening its attachment flaps. Unhook the pack opening elastics and place them aside ready for refitting at the end of the packing operations.

Freeing the Harness, Rigging Lines and Canopy from Tangle

Place the canopy gore bearing the maker's name uppermost in the centre of the table, then separate the remaining gores into two equal groups, left and right, by taking twelve lines to each side of the gore with the maker's name. This operation will indicate how the four suspension straps should pair up ; but if any of the lines are tangled, the six lines

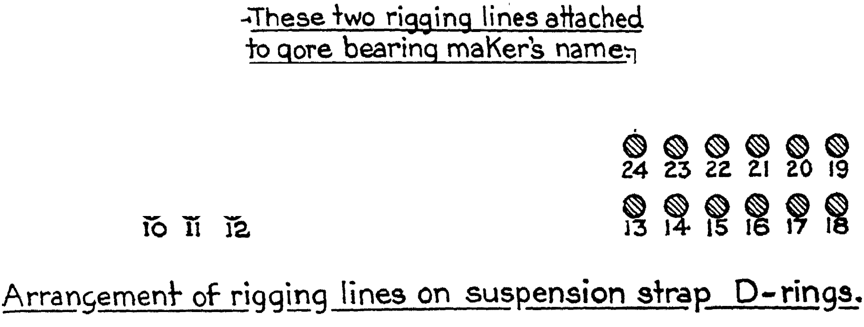

These two rigging lines attached to gore bearing maker's name
24 23 22 21 20 19
10 11 12
13 14 15 16 17 18
Arrangement of rigging lines on suspension strap D-rings.

Fig. 3.—NOTATION FOR RIGGING LINES

from each D-ring will not run clear up to the canopy and must now be disentangled. When this has been done, tangles should be removed from the harness in the following manner. Pull the harness and lines tight, and taking hold of rigging line No. 24 (see Fig. 3), shake the right-hand suspension straps until the line is free of the rest from D-ring to canopy. Then place the two right-hand suspension straps on top of one another, with D-rings together. Tangles may occur in three parts of the harness, the main suspension straps, the cross-straps or braces at the back and the main loop; separating of the lines as described above enables the tangles to be seen clearly. The two right-hand suspension straps should be traced back towards the pack cover and all twists as far as the crossing of the bracings removed by passing the pack and remainder of the harness between the main suspension straps. Twists in the cross-straps or the main loop can similarly be removed by passing the pack and seat cushion between them.

When all tangles have been removed, the harness should be laid in a face-downwards position on the table, as shown in Fig. 4. *Insert the rip cord in its housing.* The whole parachute should then appear as in Fig. 1, the canopy roughly divided into two halves, the rigging lines running down to the harness in two skeins, the suspension straps on top of each other in two pairs and the harness arranged as in Fig. 4. To check the layout, see that the two top innermost rigging lines (see Fig. 5) run to each side of the gore bearing the maker's name. If this is not the case, some mistake has been made and must be rectified before the packing proceeds farther. At this stage, in the case of a new parachute or one that has undergone repairs necessitating the separation of the canopy from the D-rings, a check should be made to ensure that the rigging lines are connected to the D-rings in the correct sequence (Fig. 6). This sequence, and the notation which has been given to the rigging lines, are shown in Fig. 3, the periphery of the canopy being viewed from the harness end.

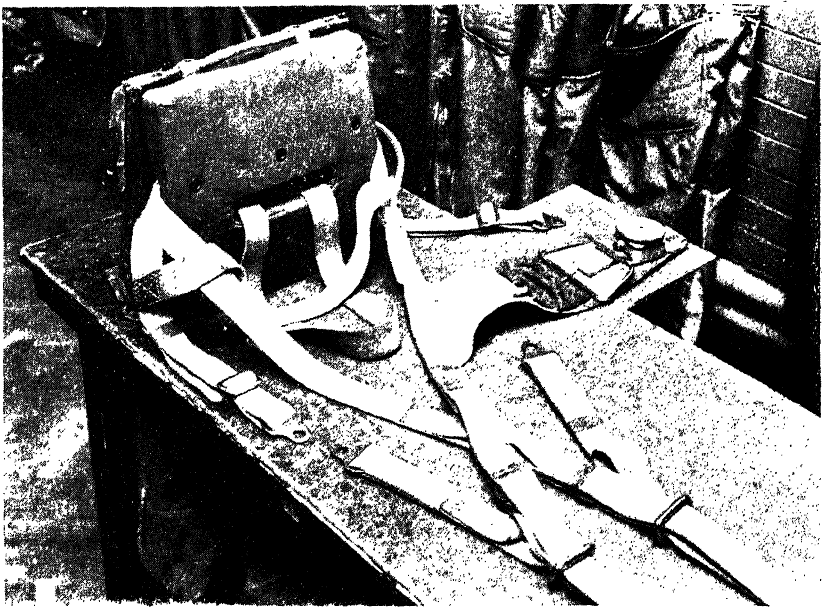


Fig. 4.—The position of the pilot-type single-point, quick-release harness, laid out ready for packing

The pack is shown on edge, to give a better view of the harness arrangement. During packing, the pack cover and cushion are allowed to lie flat.

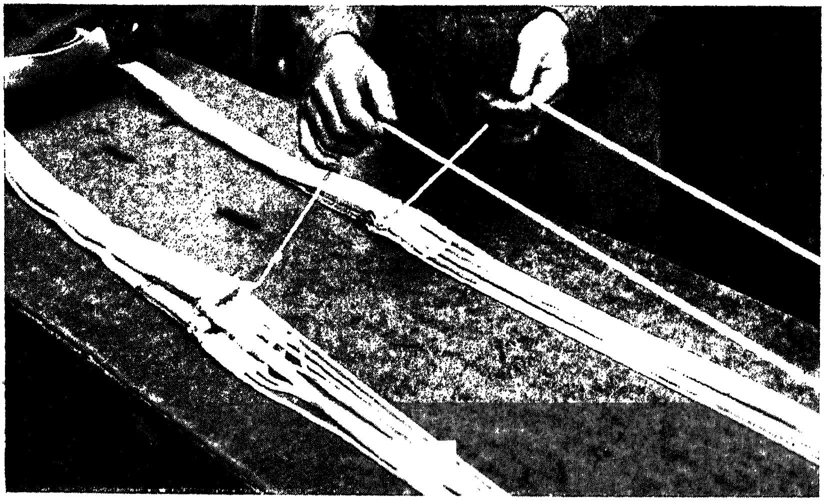


Fig. 5.—To check that the parachute is laid out correctly, see that the two innermost lines on the top suspension straps are attached to the gore bearing the maker's name

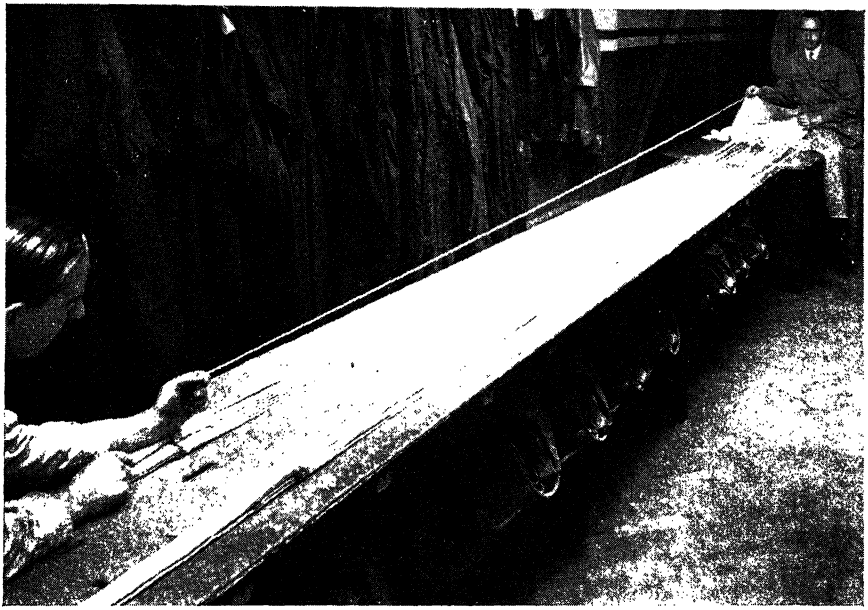


Fig. 6.—Showing how the rigging lines are checked for sequence

Adjustment of the Canopy at the Vent

If necessary, adjust the attachment of the rigging-line loops at the apex of the canopy to the hook or toggle so that the vent seam lies straight across the table, the top half of the seam coinciding with the half underneath. This is important, as if it is not done the opposite sides of the peripheral seam will not coincide and a neat folding of the canopy will then be difficult to achieve.

Folding the Canopy Gores

(*Note.*—The following instructions assume the folding in the first instance of the right-hand set of gores, though correct folding is equally well obtained if the left-hand gores are done first.)

Face the apex of the canopy, and, working on the right side of the table, take hold of No. 12 rigging line at the D-ring and follow it up to the canopy, freeing the other eleven lines of the left-hand group and moving them slightly to the left. The right-hand group of lines should at the same time be moved slightly to the right. Then, holding No. 12 line taut at the middle of the table with the left hand, take the right-hand group of rigging lines and throw the right-hand gores bodily over on top of the left-hand gores, as indicated in Figs. 7 and 8.

Then, to begin the fold, while still holding No. 12 line in the left

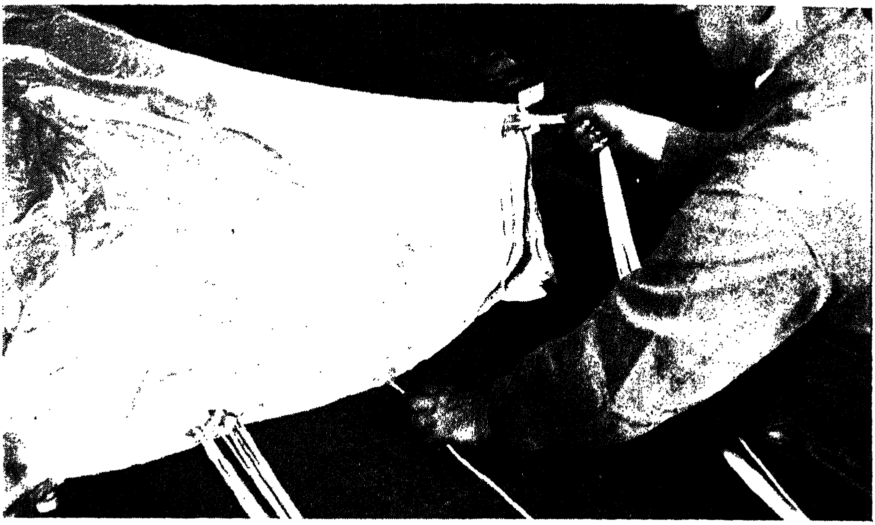


Fig. 7.—The packer's left hand is holding the first rigging line (No. 12), and the right-hand half of the gores is about to be thrown over the top of the left-hand half

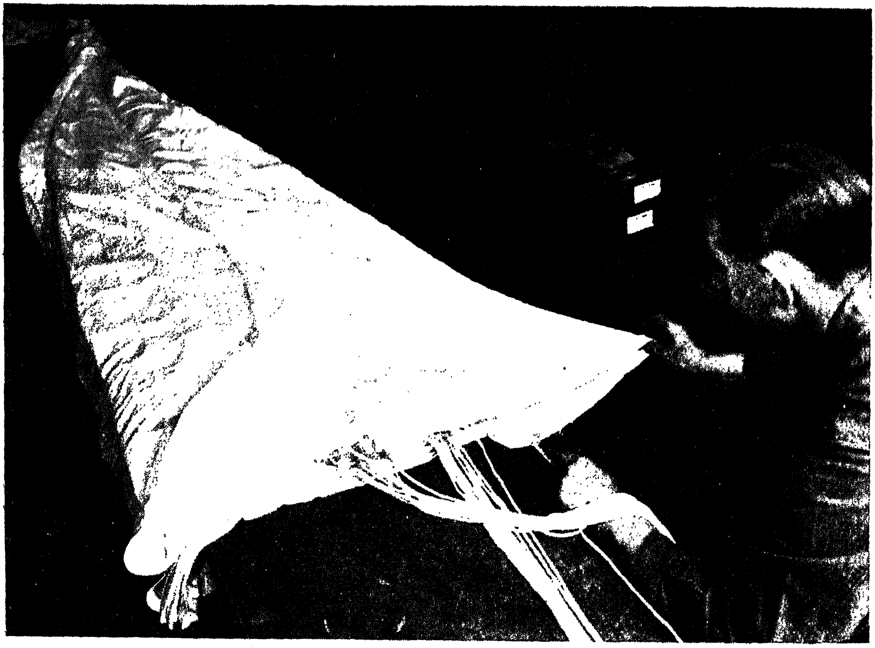


Fig. 8.—Folding the first gore (1)
Tracing out the peripheral seam.

hand, run the right hand along the periphery of the canopy to the right until the next rigging line is reached, and then, holding this taut all the time, raise it vertically above No. 12 line so as to withdraw two complete gores from the remainder. Fold both these gores in two to the right by returning the upper line to the left hand with an outward swing to the right. This folding operation is illustrated in Figs. 8–11. When the fold has been completed, take the gores at the extreme corner and, pulling them out diagonally to keep the whole quite taut, give them one or two flicks to clear any small folds or creases. Then put the corner down and retain it in position with the end of a shot bag, as shown in Fig. 12.

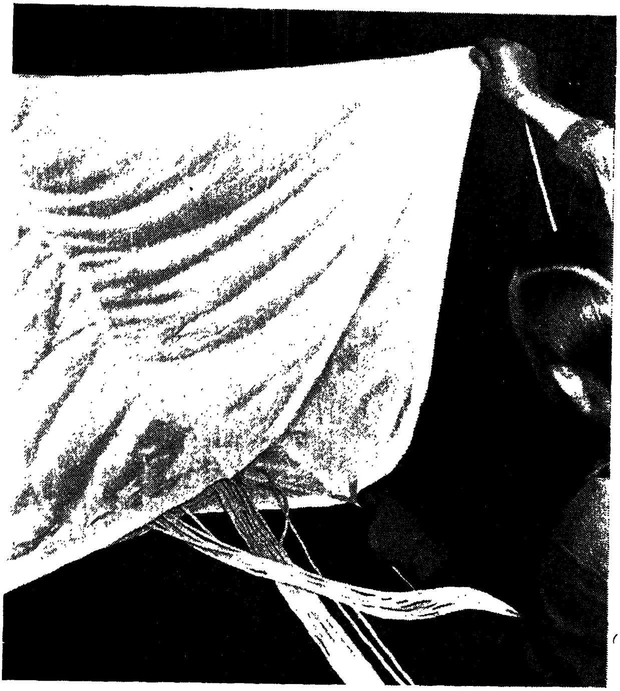


Fig. 9.—Folding the first gore (2)

The second rigging line is held and the whole gore stretched out taut vertically above the table. It will be seen that both the first and second gores are separated from the canopy.

Repeat the folding operation with the next rigging line, laying the two folded gores it brings with it on top of the first ones, and place the end of the shot bag on the corner as before. Note that to obtain the neatest result it is necessary to place the rigging lines exactly on top of each other in the left hand ; do not bunch them together in a skein. Continue the folding process until the gore bearing the maker's name is withdrawn : this marks the half-way point, and the gore should be thrown over to the left-hand set of gores. The right-hand set should then be straightened out neatly and kept in position by two shot bags, as shown in Fig. 13, one along the peripheral seams and the other parallel to the folded edges about a third of the way up.

(*Note.*—At this point the packer should move to the left-hand side of the table.)

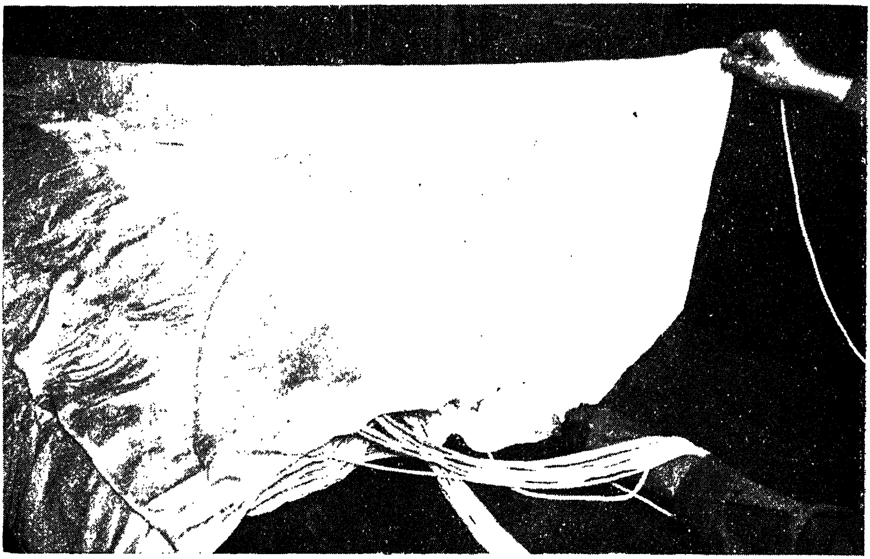


Fig. 10.—Folding the first gore (3)

Half of the gore is now allowed to drop to the table, the second rigging line still being pulled taut.

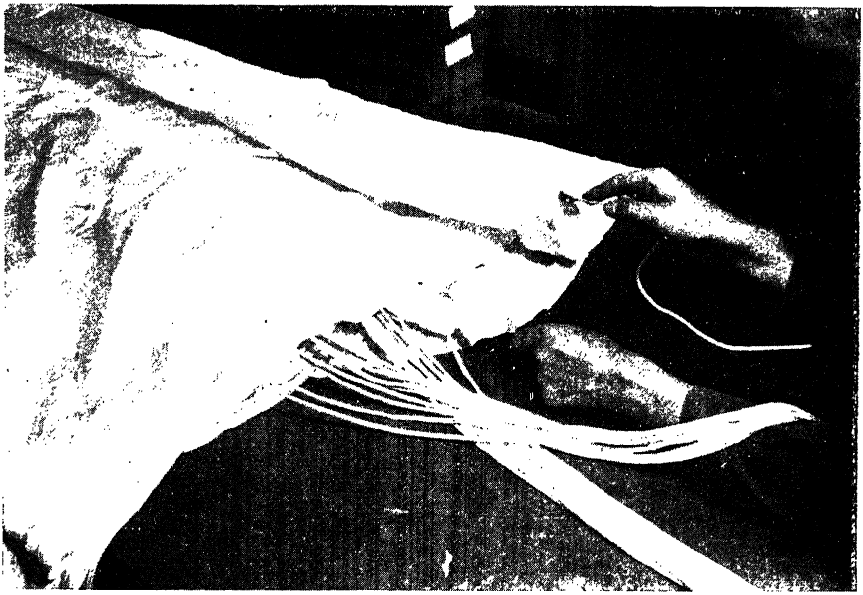


Fig. 11.—Folding the first gore (4)

This picture shows the fold nearly completed. The second rigging line held in the right hand is being brought to join the first, which is held on the table.

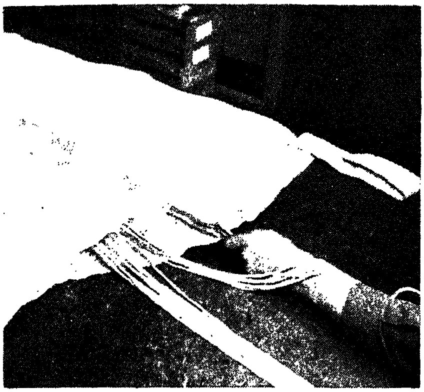


Fig. 12.—SEVERAL FOLDS OF THE RIGHT-HAND HALF OF THE GORES HAVE NOW BEEN COMPLETED

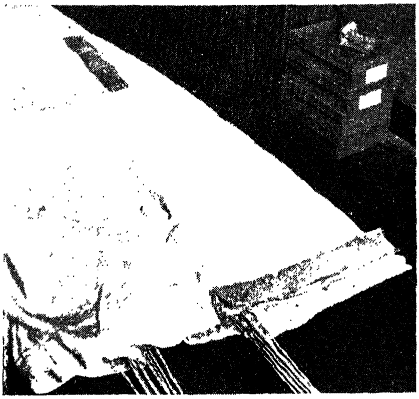
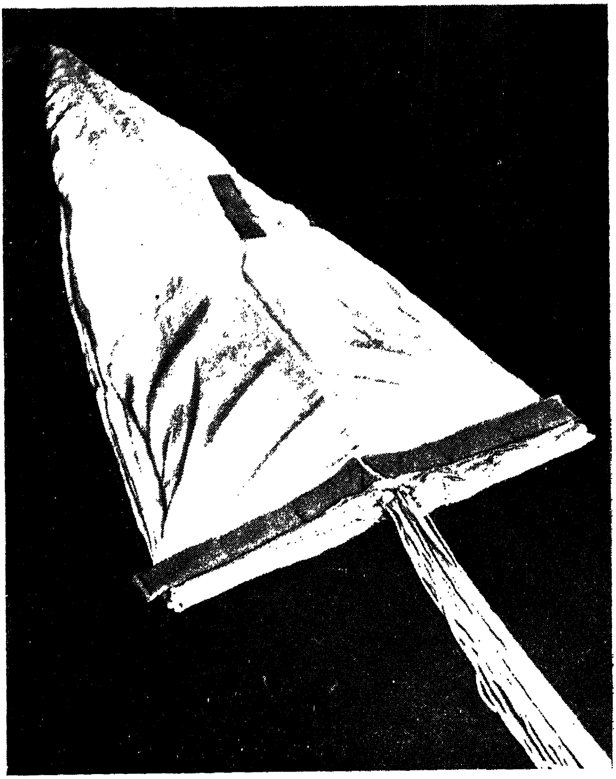


Fig. 13.—THE RIGHT-HAND HALF OF THE GORES HAS BEEN FOLDED

Fig. 14 (*right*).—IN THIS PICTURE, BOTH HALVES OF THE GORES HAVE BEEN FOLDED, AND ARE HELD BY SHOT BAGS WHICH ARE ALSO USED DURING THE TWO PRECEDING OPERATIONS



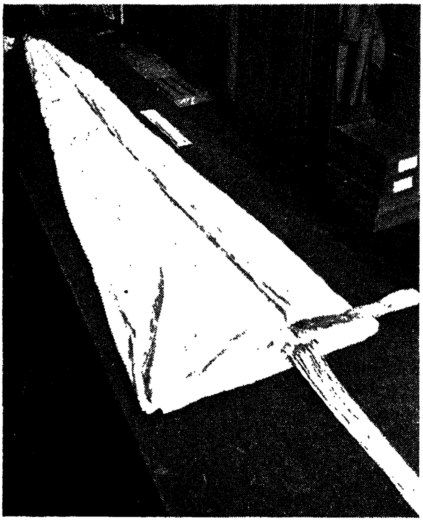


Fig. 15.—ONE HALF OF THE GORES HAS BEEN FOLDED TO THE CENTRE

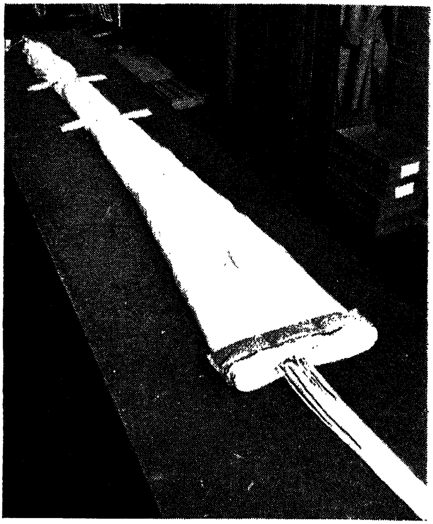


Fig. 16.—BOTH HALVES OF THE GORES HAVE NOW BEEN FOLDED TO THE CENTRE, AND ARE HELD BY SHOT BAGS

Next, the left-hand group of gores should be thrown bodily over on to the folded right-hand group ; they should then be folded in the same manner as the right-hand group and a third shot bag placed along their peripheral seams. It may be necessary, if the folding has not been expertly done, to straighten out the rigging lines inside the canopy by removing the shot bags, taking the two groups of lines, one in each hand, and giving them a few gentle jerks, first alternately and then together, keeping the hands in contact with one another.

Finally, pull the harness and rigging lines taut. The appearance of the canopy should then be as shown in Fig. 14—neatly folded and with the rigging lines grouped together at the centre with half the gores to each side.

Folding the Gore Groups to the Centre

Remove all the shot bags. Fold one group of gores towards the centre of the canopy, as shown in Fig. 15, so that the outer edges of the gores at the periphery are just overlapping the rigging lines at the centre of the canopy. Place one shot bag to hold the fold in position. Fold over the other gore group in the same way, replacing the shot bag at the periphery to hold it in place and placing the other two shot bags across the canopy near the apex, as in Fig. 16. These folds should not be taken right to the apex ; if the canopy is kept as far as possible the same width from the periphery upwards, a flatter and neater pack will result.

Stitching the Suspension Straps to the Back Cover

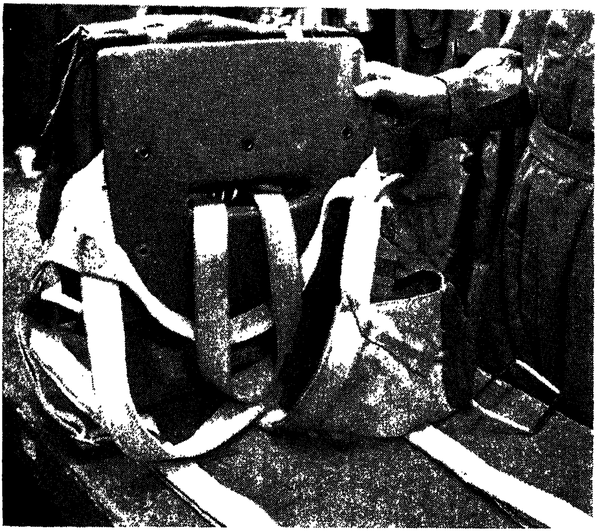


Fig. 17.—SHOWING HOW THE HARNESS AND PACK COVER ARE LIFTED INTO POSITION, SO THAT THE SUSPENSION STRAPS CAN BE FOLDED AND STITCHED

During the descent, the stitches attaching the suspension straps to the pack cover will have been broken and at this stage must be replaced. For normal routine repacking, of course, these stitches will be intact, and this operation will be unnecessary.

Leaving the shot bags in position, release the canopy apex from its fastening at the head of the table, then lift the pack cover and seat cushion from the table as shown in Fig. 17, and lay them down, cushion underneath, in the position shown in Fig. 18, with the edge of the pack so far from the D-rings that the suspension straps can be doubled back over the pack cover by an amount varying with size of the wearer and the thickness of the flying clothing normally worn. This can best be determined by experience. For a very large man the minimum amount of strap should be turned over, while for a small person the D-ring may if necessary be placed alongside the rigging-line pockets on the farther side. It is, however, advisable to err on the large side.

This done, pull on the two skeins of rigging lines and move the canopy towards the harness by an amount slightly greater than that required to enable the suspension straps to be turned back. Pass the straps through the slots provided for them at the edge of the pack cover, as shown in Fig. 19. Fold the ends over on the inside of the cover with the rigging lines to the centre and stitch them in position, as shown in Fig. 20. A single loop of No. 18 linen thread should be formed by passing the needle through the pack cover and both thicknesses of webbing, about a quarter of an inch from one edge, returning $\frac{1}{4}$ in. from the other and tying with a reef knot. The thread must be passed round the metal frame inside the cover to prevent the possibility of the fabric being torn away when the parachute is released. A sailmaker's sewing palm will facilitate the stitching.

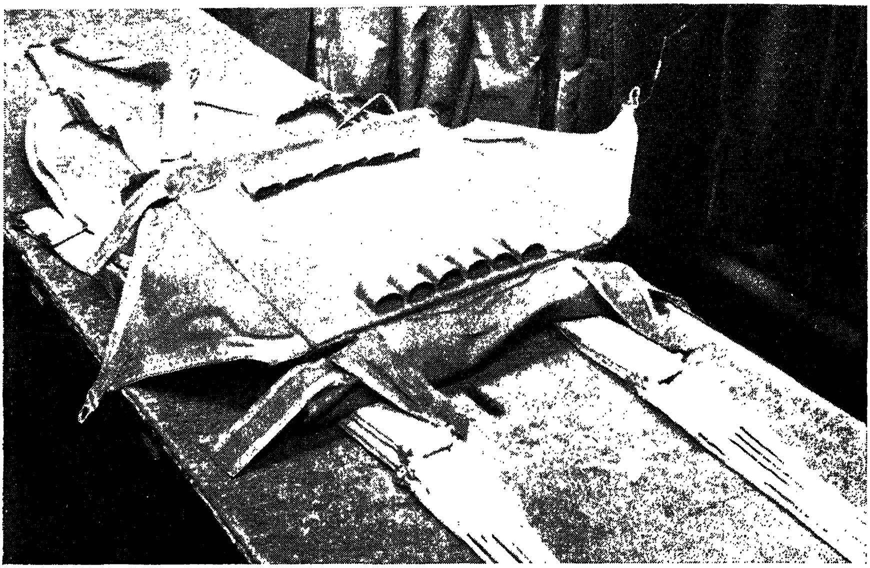


Fig. 18.—The pack cover is placed in position on the harness suspension straps at the required distance from the D-rings

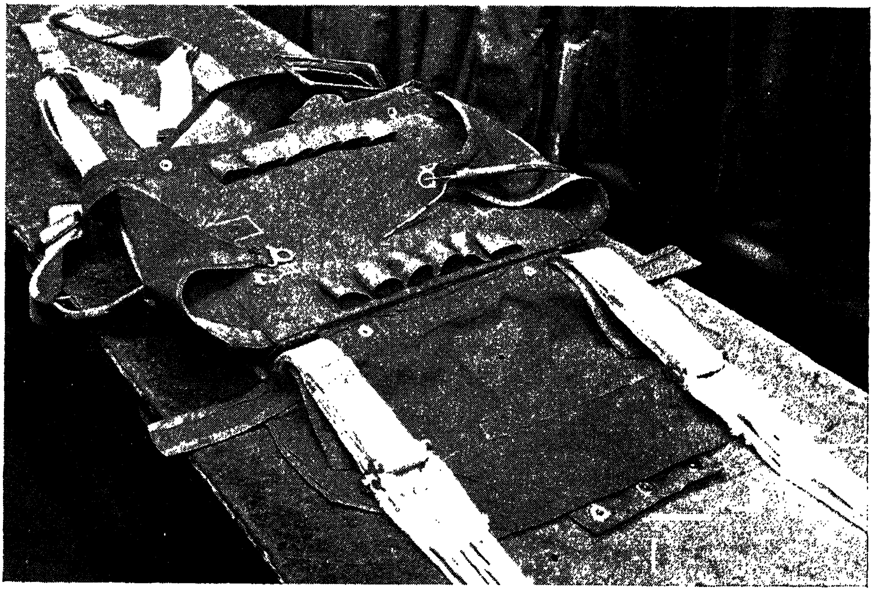


Fig. 19.—The suspension straps have been passed through the spaces in the pack cover

They are now ready for folding.

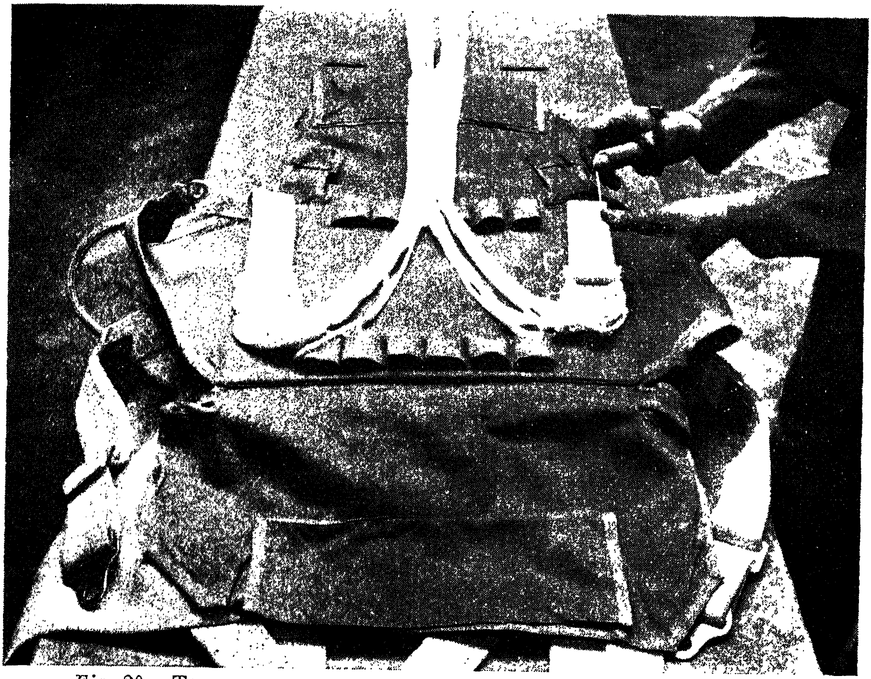


Fig. 20.—THE SUSPENSION STRAPS FOLDED BACK OVER THE PACK COVER

They are now being stitched to the pack-cover frame. It will be seen that this photograph is taken from the opposite side to the previous one.

Looping the Rigging Lines into the Pockets in the Pack Cover

During this operation the lines must be kept in tension, the shot bags being left on the canopy to assist in this direction. The lines are smooth and slippery; special care must therefore be exercised to keep them tight, straight, and without tangle between the pockets.

Collect all the rigging lines into a single skein in the left hand about 18 in. from the D-rings, and form a loop around the forefinger of the left hand, as shown in Fig. 21, leaving an equal amount of slack in each group of lines between the D-rings and the hand. Pass a rigging-line hook through the pocket on the right-hand side of the pack remote from the canopy and, engaging the hook in the loop of lines, draw the loop into the pocket, as shown in Fig. 22. The loop should not be drawn too far through the pocket, but should be left with the hook just touching the pocket, as shown in Fig. 23. The hook must be left in this position while the next loop is being positioned.

Next, draw the canopy and rigging lines towards the pack sufficiently to allow a loop to be made round the forefinger of the right hand and, using the second hook, draw this loop into the pocket opposite the first

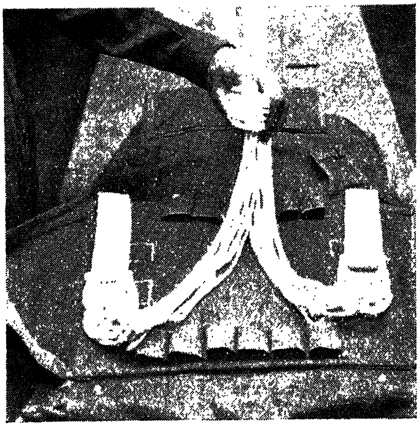


Fig. 21.—The rigging lines (1)

The rigging lines are looped round the forefinger, ready for engagement with the rigging-line hook. There is an amount of slack left between the D-ring and the first loop in the lines.

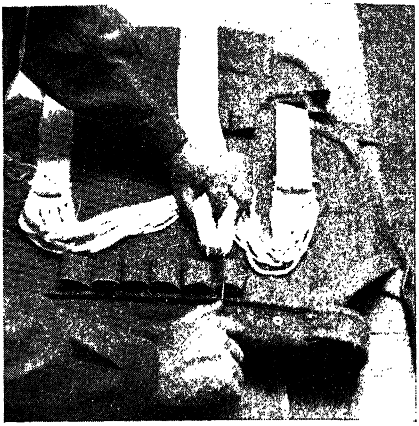


Fig. 22.—The rigging lines (2)

The first loop is shown engaged with the hook and being drawn into the pocket.

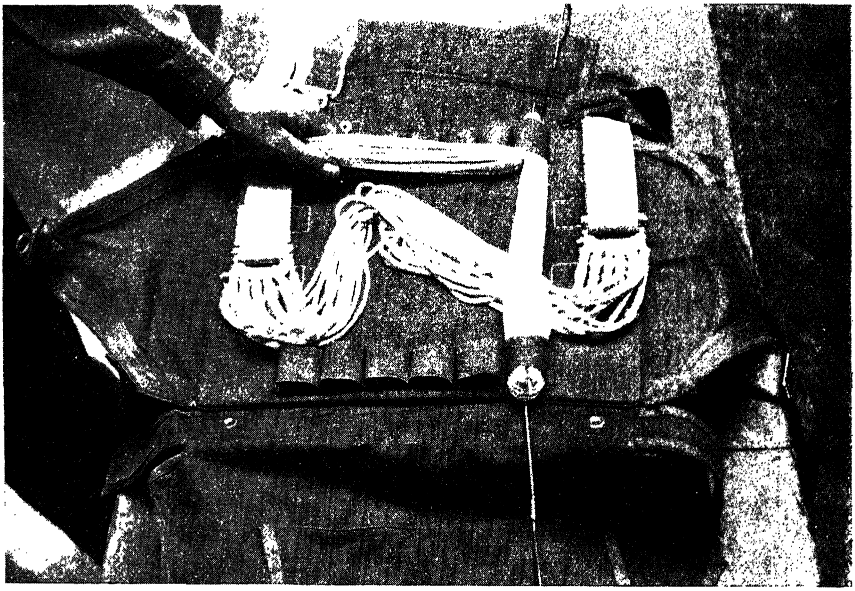


Fig. 23.—The rigging lines (3)

The first and second loops are shown in their pockets and the third loop is just being formed. The lines between the pack cover and the canopy should be kept as taut as possible and the hooks should be left in the pockets (as shown) until actually required for a new loop.

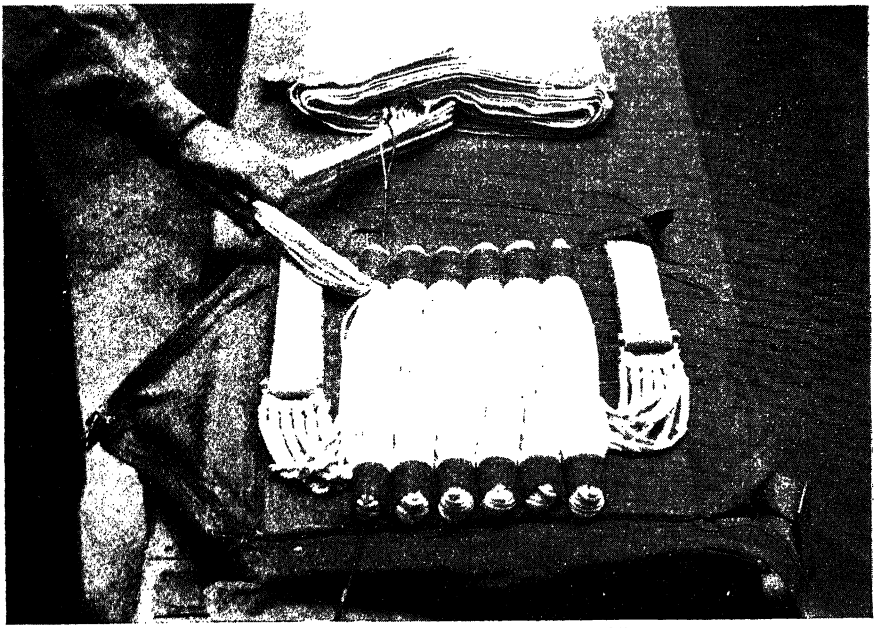


Fig. 24.—The rigging lines (4)

This picture shows all the rigging lines looped in the pack-cover pockets.

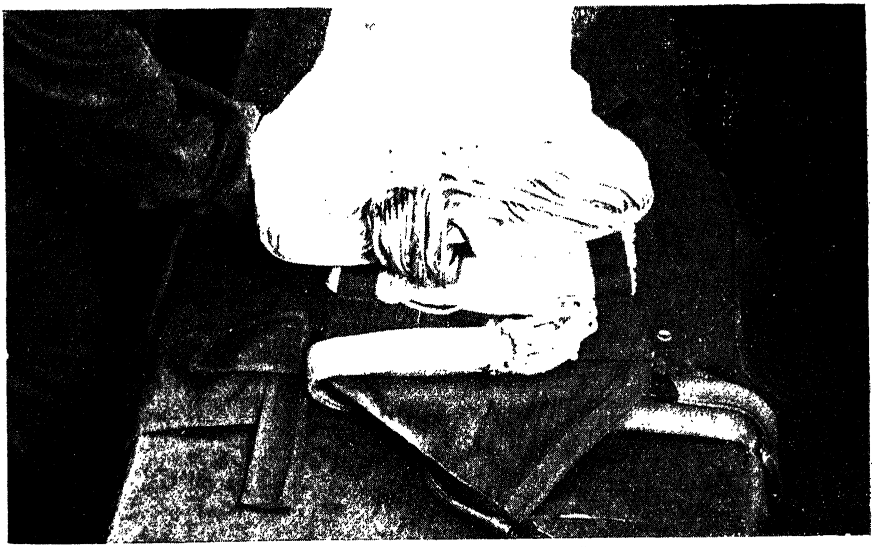


Fig. 25.—The periphery end of the canopy is held 6 in. above the pack cover

The pack cover has been rotated a quarter-turn anti-clockwise.

one to be filled, keeping all lines as tight as possible in the process. The hook should, as before, be left in position during the insertion of the next loop. Fig. 23 shows the first two loops in position and a third about to be formed over the forefinger of the left hand, after which it will be drawn into the appropriate pocket by the first hook. When forming a loop in the stretched lines, it should with practice be possible to judge accurately the length necessary to reach the next pocket, thus avoiding the necessity for adjustment to the lines after the loop has been inserted. If an error does creep in, however, adjustment is effected by maintaining a light tension on the free line while working the hook gently into or out of the pocket as required.

Continue the operation until all the pockets have been filled (Fig. 24), then withdraw both hooks. The canopy will now have been drawn close to the pack, the length of the free lines being about 18 in., and the parachute is ready for the operation of piling the canopy.

Piling the Folded Canopy on the Pack Cover

Move the shot bag from the periphery to the upper portion of the canopy. Place the left hand under the periphery and raise it 6 in. above the table, at the same time placing the right hand on the rigging lines in the pack cover and giving the cover and harness a quarter turn in an anti-clockwise direction (see Fig. 25). Lower the canopy on to the pack cover so that the peripheral seams are directly over the pack-cover frame on the short side, with the folds 1 in. wider on each side than the frame. This extra width, shown clearly in Fig. 26, results in a flatter and more compact pack. The original folding of the canopy into three (Fig. 16) was only an approximation to the correct width and any necessary alterations to the folds should be made at this stage, taking care, however, that the folded gores in each half of the canopy are kept neatly on top of each other. The operation of making the first fold in the canopy is shown in Fig. 27. Place the right hand on the canopy directly over the pack-cover frame on the left-hand side, place the left hand under the canopy at a distance to the left of the right hand approximately equal to the length of the pack-cover frame. Raise the left hand and move it over the right hand, making a double fold in the canopy and dragging the apex end with the shot bags along the table. Do not pay much attention to the fold made by the left hand on the right-hand side, but ensure that the fold made by keeping the right hand firmly in place is clean, straight and in the correct position. The fold over the peripheral seams is now completed, using both hands and pulling only on the top layer of fabric. From Fig. 28 it will be seen that the fold at the peripheral end is made short of the seams in order to maintain a uniform thickness throughout the three layers. Subsequent folds at this end are taken to the full extent of the pack cover and are located directly over the pack frame.

The bulk of the canopy decreases towards the apex ; to make allow-

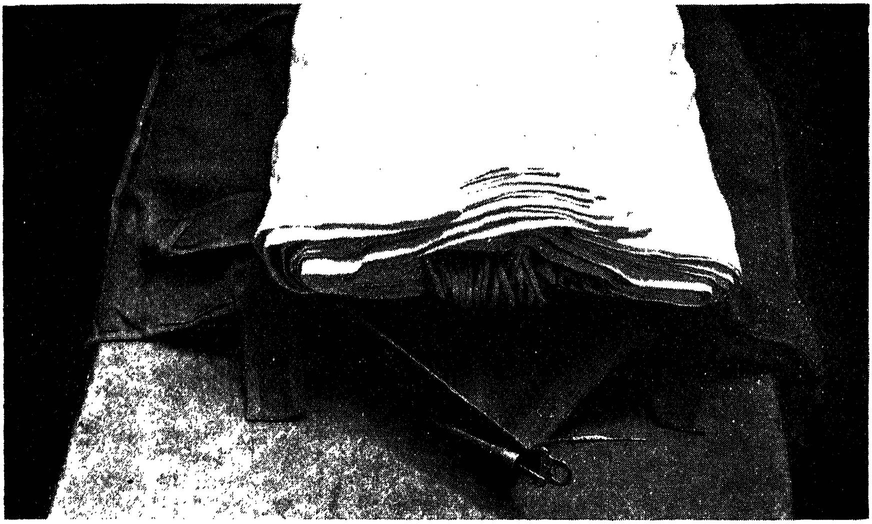


Fig. 26.—THE CANOPY IS LAID ON THE PACK COVER

The peripheral seams are directly over the frame at the rip-cord end. It will be seen that the canopy is about 1 in. wider than the pack-cover frame at each end.

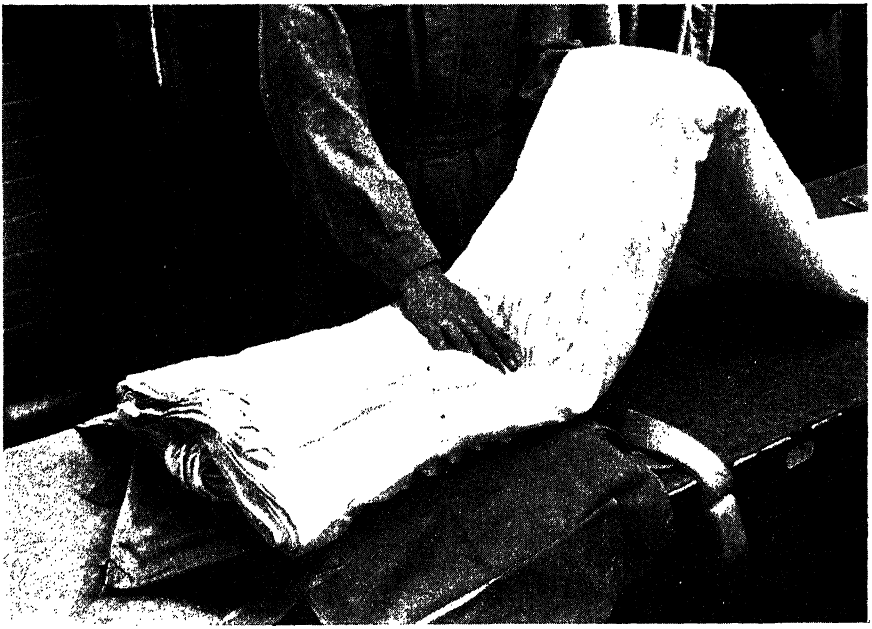


Fig. 27.—PILING THE CANOPY ON THE PACK COVER (1)

The first fold is being made.

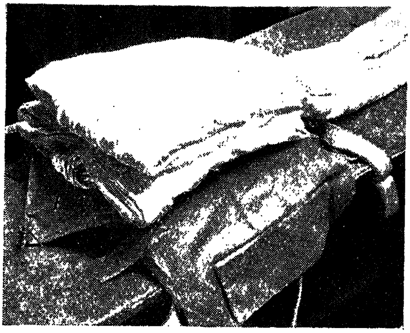


Fig. 28.—Piling the canopy on the pack cover (2)

The first fold (which is made short at the rip-cord end, to compensate for the extra thickness of the peripheral seams) is completed.

Fig. 29.—Piling the canopy on the pack cover (3)

The apex is tucked beneath the top fold and the canopy is completely piled on the pack cover.

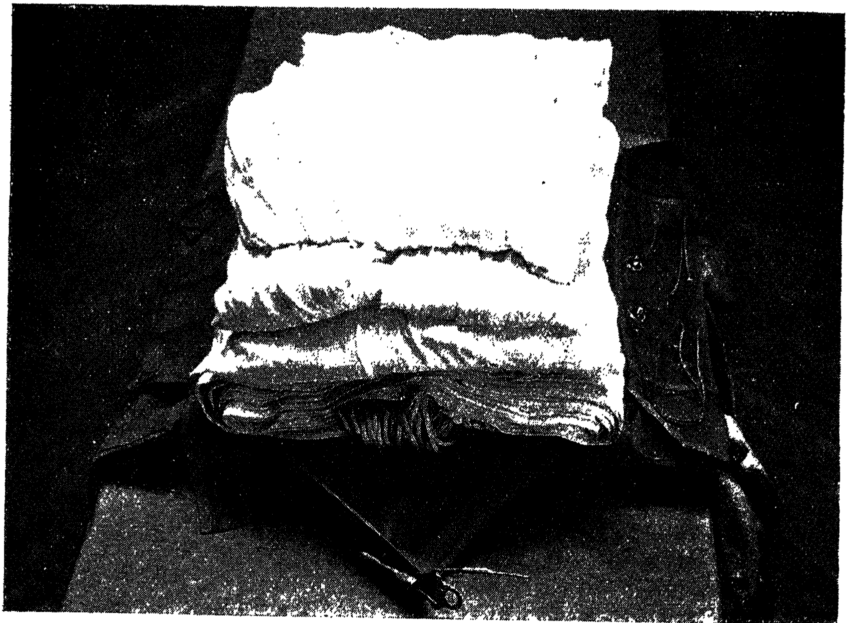


Fig. 30.—The pieces of cord are now placed through the locking cones, ready for closing the side flap ance for this it is necessary to pull out the fabric to each side when a fold has been completed so that the limits of the folded canopy remain the same as the first layer, producing a slight hollow in the middle. This precaution is important, as a void at the edge will increase as a result of movement in use and the action of the pack elastics, and it is then quite possible for the pack frame to be broken by rough treatment even in the aeroplane.

Continue folding the canopy until there is insufficient left to form a complete fold. It will be noted that the whole of the last fold which is made in the narrow portion of the canopy near the apex will lie in the hollow formed by spreading the preceding folds. After the last complete fold has been made, about 9 in. of the apex should be left over. This, together with the rigging lines at the apex, must be folded *under* the topmost layer in order that there is no possibility of the auxiliary canopy becoming entangled with rigging lines at the apex. The folds should now be adjusted carefully and the pile made as neat and square as possible, as illustrated in Fig. 29. The auxiliary parachute extension piece leads out of the pile on the end opposite that to which the rip-cord housing is attached.

Closing the Pack Cover

This is the one part of the packing sequence needing practice and manual dexterity to achieve a good result if only one person is doing the packing. It will help considerably if, before starting this operation, all the tools and equipment required are placed conveniently at hand.

In the closing of any pack the auxiliary parachute is always inserted after the side flaps and the end flap carrying the rip-cord housing have been closed; it is therefore important that the auxiliary parachute extension piece should be led out of the pack on the correct side, as described above. If an assistant is available to help with the packing the parachute may at this stage be removed to the smaller table, but with single-handed packing this presents no advantage.

Insert a piece of cord through the hole in each of the pack locking cones, as shown in Fig. 30, and fold over the auxiliary parachute flaps, the one on the grommet side first, as shown in Figs. 31 and 32. Then pass one of the cords through the grommet, and by pulling on it, draw the locking cone through the grommet and secure it temporarily with one of the packing pins, as shown in Fig. 33. Repeat this procedure with the other locking cone, leaving both cords in position. At this stage make sure that the auxiliary parachute flaps are straight and properly overlapped. Fig. 34 shows the pack at this juncture. Now rotate the parachute through a quarter-turn in an anti-clockwise direction to the position shown in Fig. 35. Pull up the end flap carrying the rip-cord housing, hold it in position with the left hand as shown in Fig. 35 and thread both

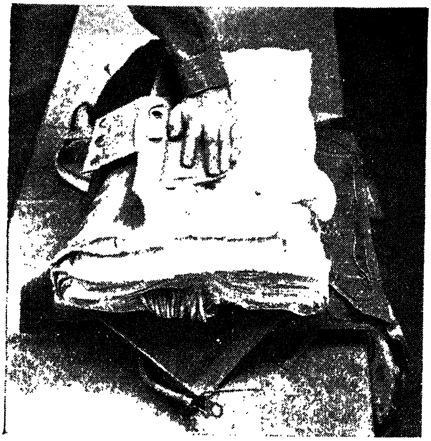


Fig. 31.—The side flap bearing the grommets is pulled over the canopy by its auxiliary parachute flap

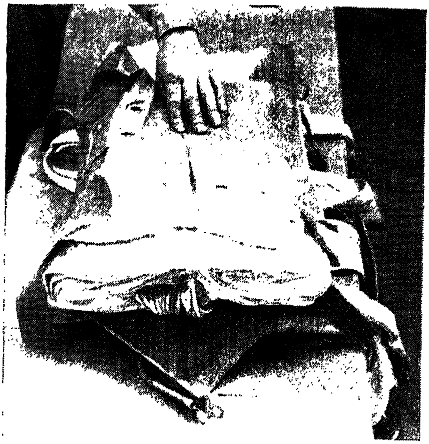


Fig. 32.—The two auxiliary parachute flaps are overlapped

doubled cords through its lug eye. Then pull with the right hand on the double cord from the cone nearest the body until the lug eye is positioned over the cone to be locked (Fig. 36) and wind the cord from that cone around the left hand so that it can be pulled up through the lug eye when the temporary pin is withdrawn. Before releasing the cords from the right hand, clamp them down with the left thumb so that they do not

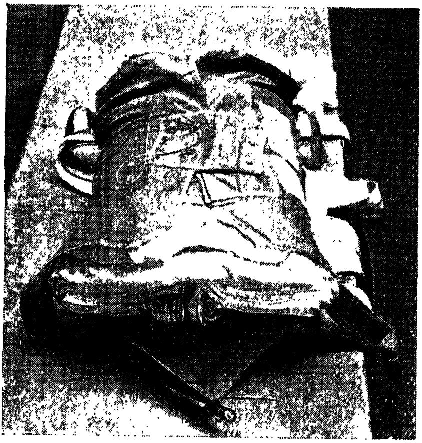


Fig. 33.—The two side flaps are closed and held by one temporary pin

The procedure is repeated with the other locking cone, leaving both cords in position.

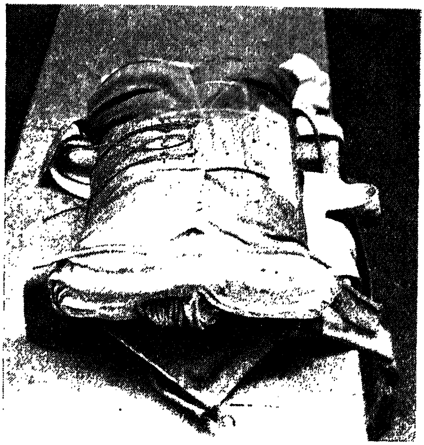


Fig. 34.—Both temporary pins are inserted, and the side and auxiliary flaps smoothed out

All corner flaps are pulled out from the pack.

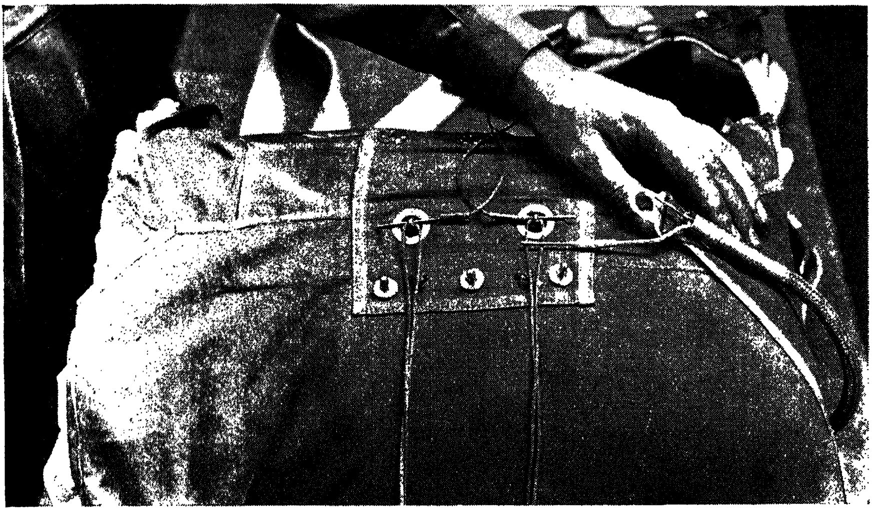


Fig. 35.—THE END FLAP AT THE RIP-CORD END IS PULLED OVER AND HELD READY FOR THREADING THE PIECES OF CORD THROUGH THE LUG EYE

slip, then pull out the temporary pin as shown in Fig. 37 and replace it by the rip-cord pin, using the free length of rip-cord cable with the second pin attached to guide it into place. Fig. 38 shows the completed operation. When this has been done, place the rip-cord ring in its pocket to

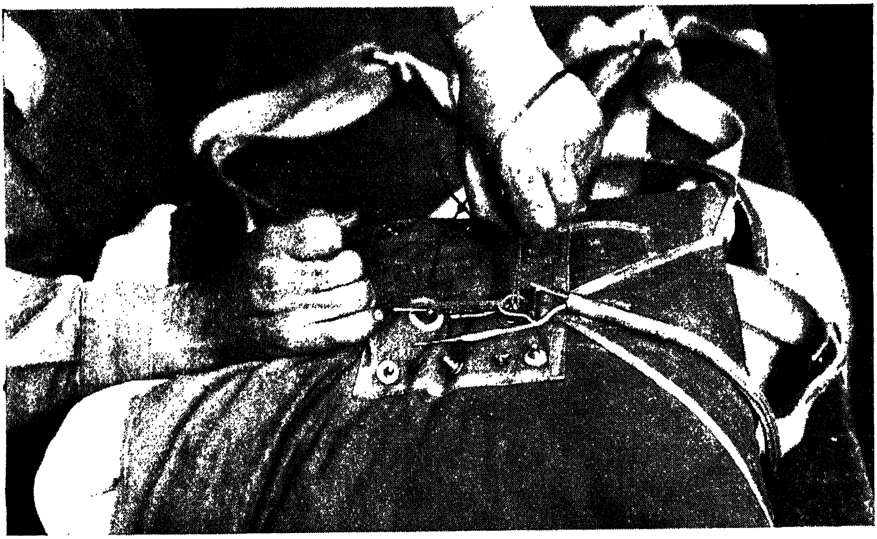


Fig. 36.—THE PIECES OF CORD BEING USED TO BRING THE LOCKING CONES UNDER THE LUG EYE READY FOR INSERTION OF THE RIP-CORD LOCKING PIN

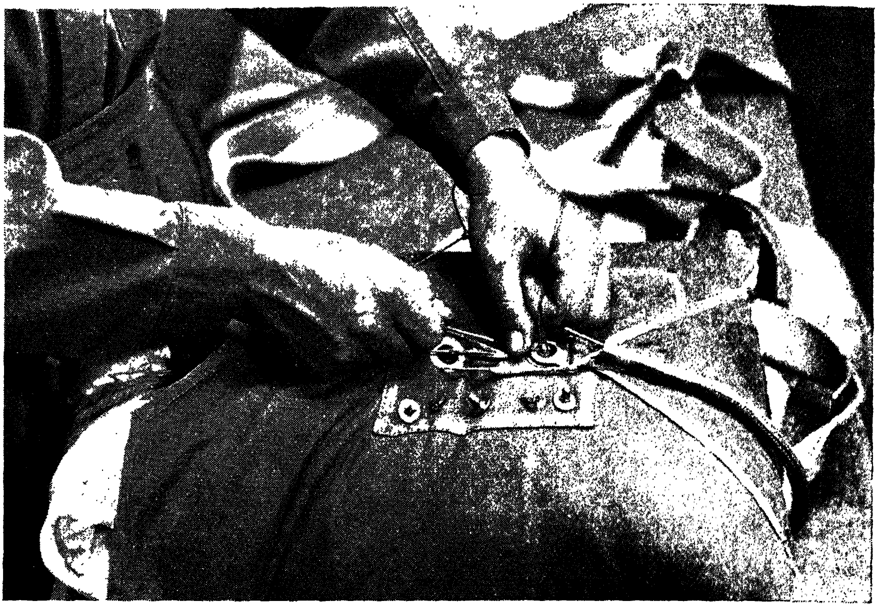


Fig. 37.—THE LUG EYE IS PLACED OVER THE LOCKING CONE AND HELD BY THE THUMB AND CORDS, WHILST THE TEMPORARY PIN IS WITHDRAWN AND REPLACED BY THE RIP-CORD LOCKING PIN

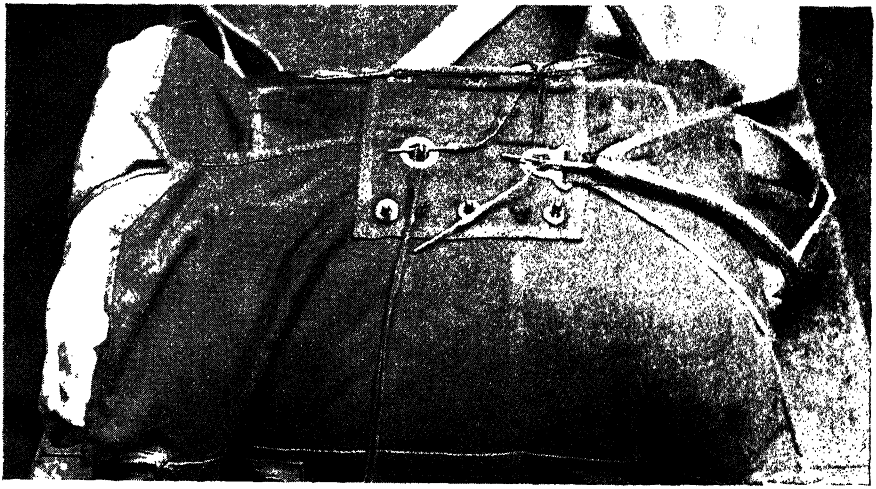


Fig. 38.—THE END FLAP AT THE RIP-CORD END IS CLOSED AND HELD BY THE RIP-CORD LOCKING PIN

The rip-cord ring is now placed in its socket.

prevent the rip-cord pin being pushed out of its cone when the second pin is being inserted. Withdraw the cord from the lug eye on the end flap just closed, but leave both cords threaded through the cones as shown in Fig. 38 to assist in closing the remaining flap.

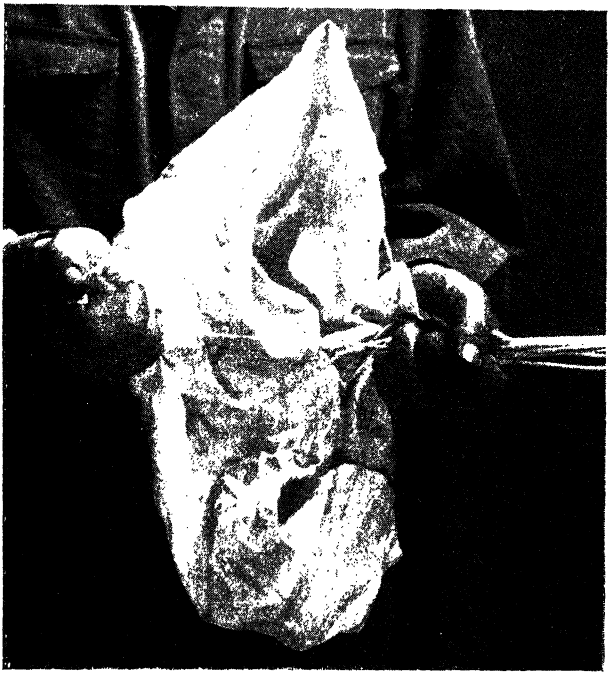


Fig. 39.—THE AUXILIARY PARACHUTE (1)

The picture shows the auxiliary parachute being folded. The peripheral edges are drawn to the centre and the rigging lines are held against one rib.

Packing the Auxiliary Parachute

The auxiliary parachute must first be folded. Hold its rigging lines by the loop to which the auxiliary parachute extension piece is secured and allow the parachute to dangle freely over the edge of the table, straightening the rigging lines if necessary. Run the right hand down the lines to draw the peripheral edges of the auxiliary towards the centre. Then, retaining the hold with the right hand, take hold of a rib with the left and tilt it upwards towards the skein of rigging lines, eventually closing the left hand round the skein and rib, and wrapping the silk around the skein as shown in Fig. 39. Then, holding the parachute with the left hand, fold the remaining ribs into it, beginning with the opposite rib as shown in Fig. 39, folding the silk round the ribs in the process. When this has been done, gently tug the rigging lines to withdraw any surplus length enclosed within the canopy. Now insert the auxiliary parachute, apex first, between the topmost auxiliary flap and the pack-cover flaps, as shown in Fig. 40, working the apex along the seam joining the auxiliary parachute flap to the pack cover on the side of the locking cones remote from the lift-the-dot fasteners. When the auxiliary is in position, fold the extension piece and the rigging lines backwards and forwards into a neat bundle in the hand and tuck them away between the auxiliary parachute flaps.

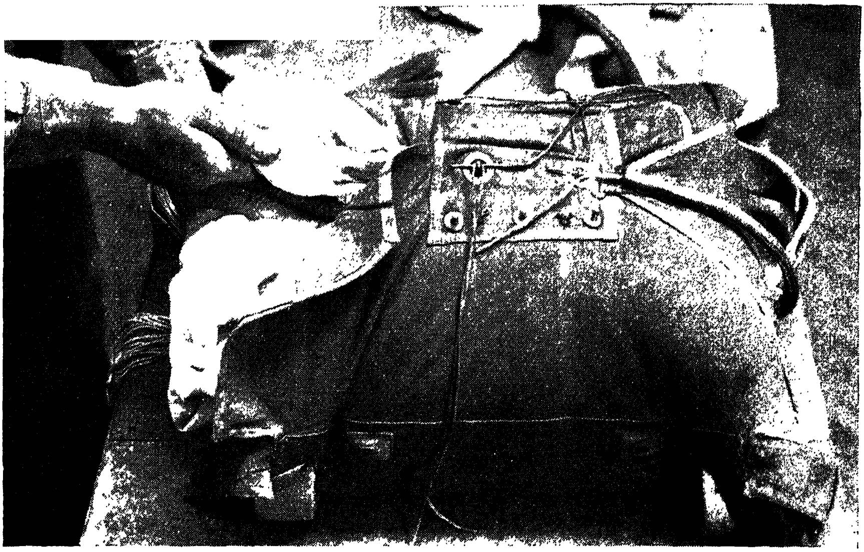


Fig. 40.—The auxiliary parachute (2)

After folding, the auxiliary parachute is inserted, apex first, into the pack.

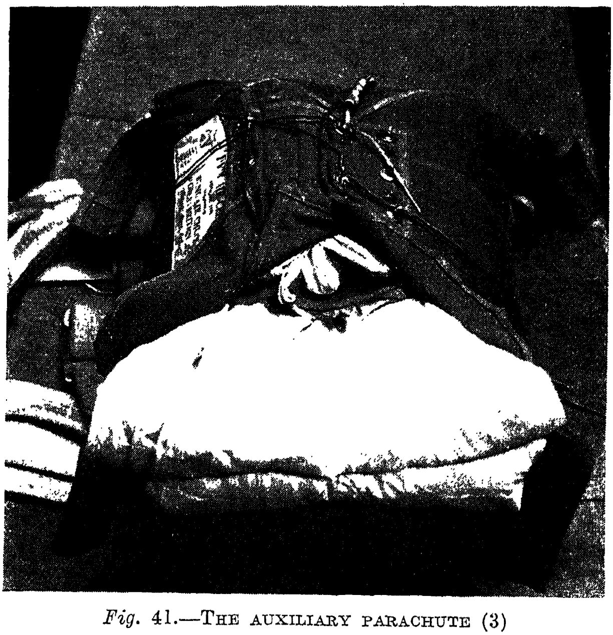


Fig. 41.—The auxiliary parachute (3)

The auxiliary parachute is in place and its rigging lines are tucked between the auxiliary parachute flaps.

Closing the Remaining End Flap

When the auxiliary parachute has been packed away, pass both double cords from the locking cones through the lug eye of the remaining end flap and proceed to lock the flap in position with the rip-cord pin in a manner similar to that described for the first end flap. When the rip-cord pin is in position, withdraw both cords from the locking cones in the direction in which the rip-cord pins were inserted so that there is no tendency for the pins to be withdrawn with the cords.

Fig. 42.—Showing the corner flaps being pushed into place with the packing stick

Tucking in the Corner Flaps

At this stage the pack should be worked into the correct shape by light pummelling with the hands and the use of the packing stick. The stick may be used with a see-saw motion under the end flaps, but when this is done care must be taken to insert from the side remote from the rip-cord protecting flap fasteners, otherwise it may enter between the side flap and the canopy and disarrange the folds in the latter. Then tuck the corner flaps firmly into place with the assistance of the packing stick, which is inserted in the pockets provided in the flaps for this purpose. An opening may be made by raising the silk of the canopy near the corners with two fingers. Fig. 42 shows this operation.

Fitting the Pack-opening Elastics

Turn the pack upside down and engage first the elastics running across the width of the pack (these also run under the main harness straps) and then the two running along the length of the pack. The eyes for each elastic are duplicated, so that the elastics can be arranged so that they do not cross one another. The hooks should be passed through the eyes so that the points of the hooks are outwards ; this helps to avoid wear.

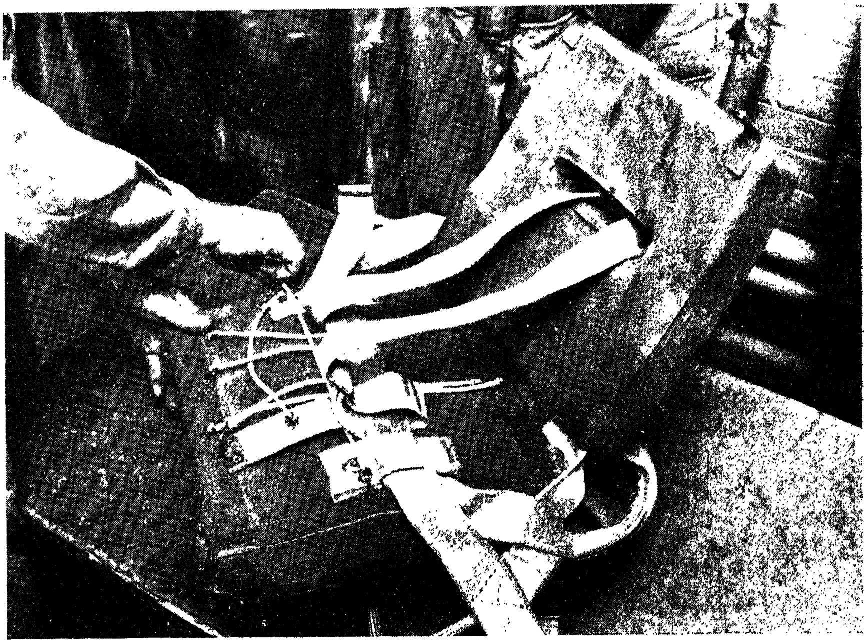


Fig. 43.—Here one pack elastic is being fastened, to keep the remainder in place

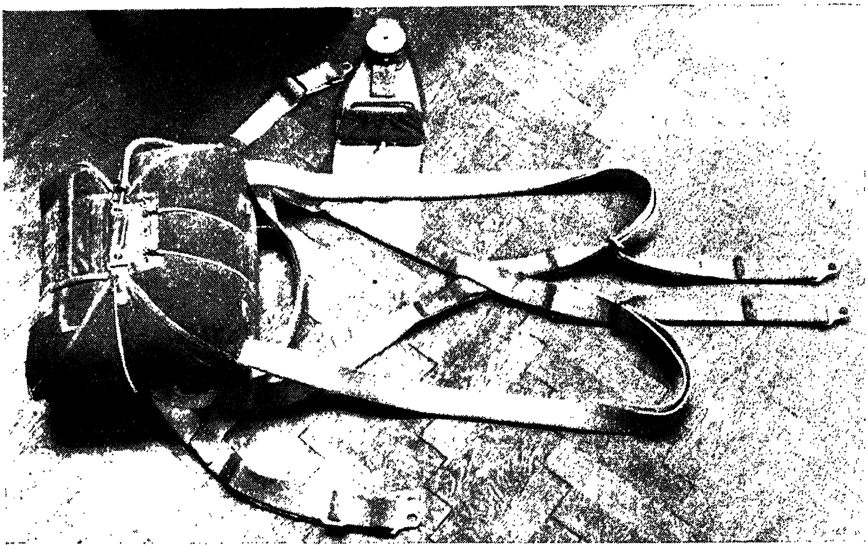


Fig. 44.—The pack is completed, with the exception of the fastening of the rip-cord protecting flap

It is shown with the harness laid out for attachment of the back pad.

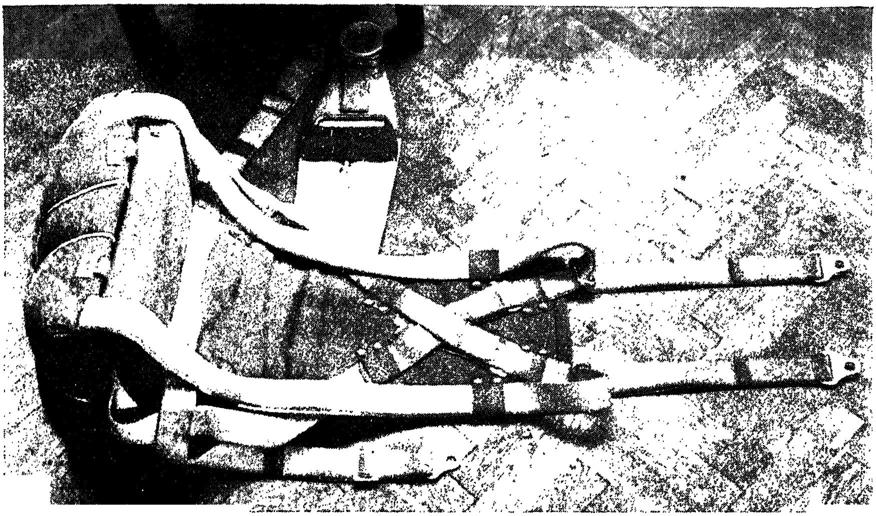


Fig. 45.—This picture shows the completed parachute

One of the longitudinal elastics should first be engaged with the eye on one of the end flaps, this keeping the other elastics in position (Fig. 43); the remainder should then be engaged with their corresponding eyes. Refasten the seat-cushion tabs to the pack cover.

Rip-cord Safety Thread

When the pack elastics have been engaged, pass a doubled length of special safety thread under the rip-cord pin farthest from the rip-cord housing and on the outer side of the locking cone. Now secure it to the cable by three half-hitches immediately behind the joint between the pin and cable, as shown in Fig. 46. No other thread must be used. The safety thread is to prevent the rip-cord pins slipping out of the cones; they should not be strong enough to offer any serious resistance when the rip cord is pulled. The rip-cord protecting flap must then be snapped in position.

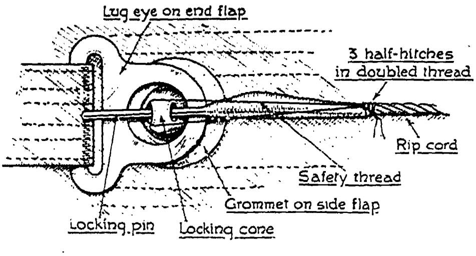


Fig. 46.—Method of securing scarlet safety thread to the rip-cord locking pin

Fitting the Back Pad

Lay out the parachute and harness in the "face-downwards" position (Fig. 44); raise the harness by means of the front suspension straps and slip the back pad underneath in approximately the correct position for fitting.

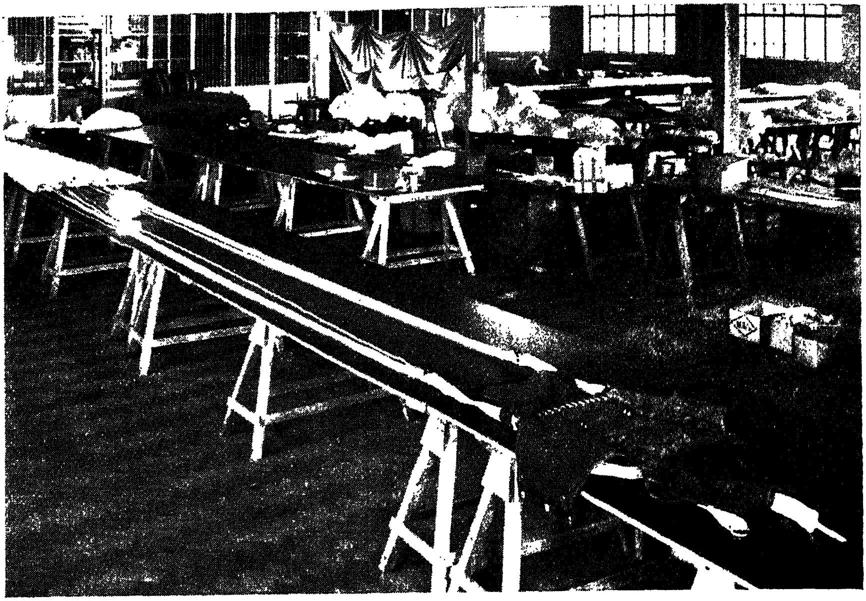


Fig. 47.—PACKING THE G.Q. PARACHUTE

Showing parachute stretched out on the packing table. The lines at the apex are attached to a hook on the table.

First fasten the two flaps at the top of the pad holding the braces, then fasten the remainder in any order. The quick-release having been tested to make certain that it is working properly, the parachute is ready for use (Fig. 45).

PACKING OPERATIONS (G.Q. PARACHUTE)

Carefully stretch out the parachute on a packing table and attach the lines at the apex to a hook on the table. It should have been hung up to dry for twenty-four hours before proceeding. On no account should it be packed in a damp or wet condition. The spring of the pilot parachute should be tested and if the pressure required to close it has fallen below 4 lb., a new one should be fitted. It is most important that the brass cones and gromets on the pack covers should be examined. Any roughness on the cones may be removed with fine emery cloth and a broken or damaged gromet immediately replaced. Gromets and cones are liable to damage through careless use of pins while packing and as the release of the parachute depends on the free movement of these parts the importance of adequate inspection cannot be overestimated.

The rip-cord housing should be inspected for chafing of the cover or crushing of the core. The rip cord should be looked at and must be kept well covered with grease to prevent rust.

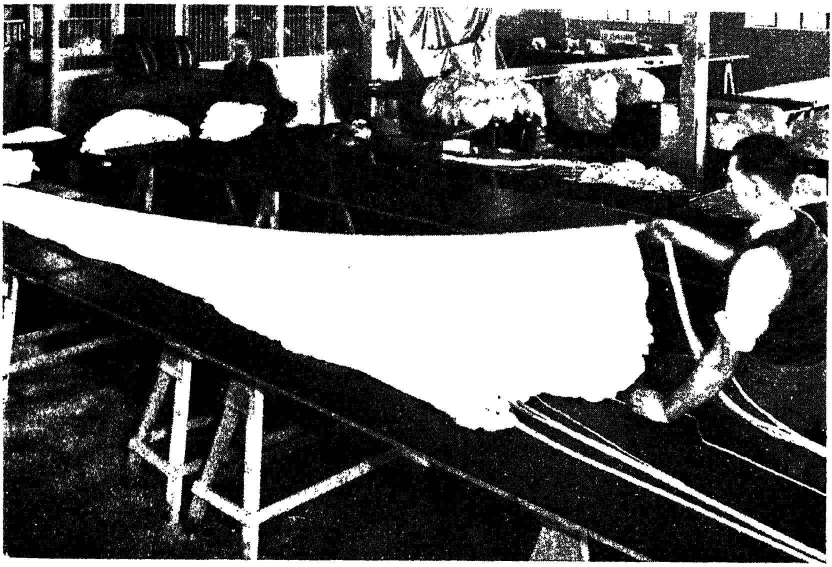


Fig. 48.—FOLDING IS STARTED ON THE RIGHT-HAND SIDE OF THE TABLE, THE RIGHT-HAND HALF OF THE CANOPY AND LINES BEING MOVED OVER ON TO THE LEFT-HAND GROUP

Shroud-line loops must hold the lines firmly in place. The canopy and lines should be inspected, although little damage can occur to these parts.

The pack of the G.Q. has received special attention with regard to wear, and it will be seen that a large strip of webbing has been fitted to the parts most liable to damage. The elastics should be immediately changed if any doubt is felt about their strength and should always be unhooked when the parachute is not in use.

Having inspected the parachute, proceed to fold it, after having made certain that all the lines are free. If No. 1 line stretches from No. 1 lift web through to the apex of the canopy without any other line crossing it, then all the other lines must be free.

Make sure also that the harness is not in any way entangled.

This being done, now lay the harness on the table in such a way that if it were attached to the wearer he would be lying on his stomach.

Commencing on the right-hand side of the table, move the right-hand half of the canopy and lines over on to the left-hand group. Take No. 13 line in the left hand, holding it firmly, and move a finger of the right hand along the edge of the canopy until No. 12 line is reached. Take it over to the right as far as the gore of silk will allow and draw it back to the left hand. We have thus folded the first gore. Then get No. 11 line and do the same as with No. 12. Continue until the right-hand half is folded. Place three or four canvas weights loaded with lead shot on the folded part

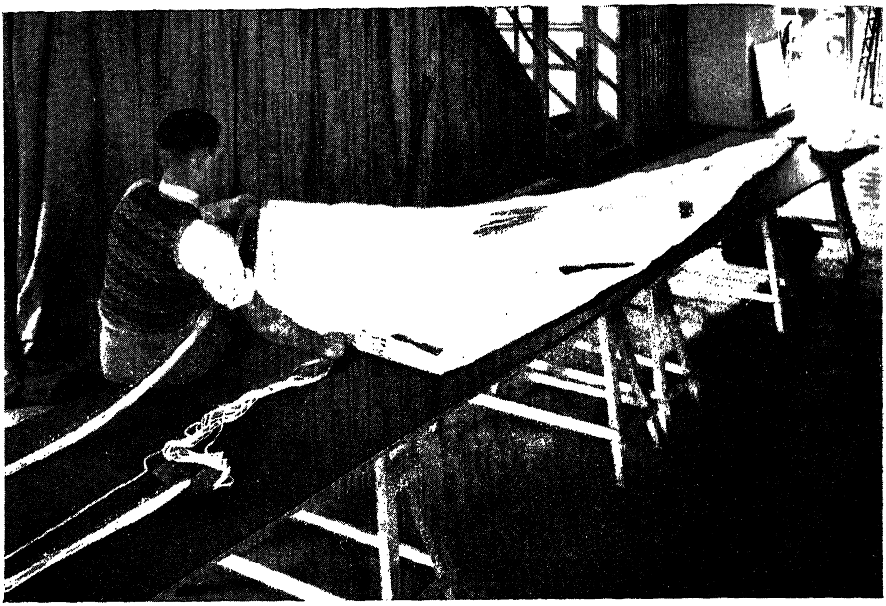


Fig. 49.—THE UNFOLDED LEFT-HAND SIDE OF THE CANOPY IS NOW THROWN OVER ON TO THE FOLDED PART

to hold it in position. Now go to the left of the table and throw the unfolded left-hand side of the canopy over on to the folded part. With the twelve lines of the folded part held firmly in the right hand, proceed to fold the remaining twelve gores as was done with the right-hand half. The canopy is now as one long triangle and the lines will be together down the centre.

Remove the weights and take one group of folded gores and lay them toward the centre. Repeat with the other group and the canopy will now have a width approximately that of the pack. Hold down with the weights.

Lift the pack frame and place within a foot of the D rings on the harness. Fold the lift webs back over the frame and fasten by passing the tab on one lift web through the D on the other and secure the tab to the press-studs on the pack.

Commencing at the top right-hand corner of the pack frame and with the help of a hook insert the shroud lines to and fro into the loops. Now fold the canopy back and fore on the pack with the mouth towards the rip-cord end.

Pass a piece of strong light cord through each cone, and with the aid of these cords pull up the shorter of the two side flaps and engage gromets in same over the cones in the end flaps, securing temporarily with packing-

Fig. 50.—EACH GROUP OF FOLDED GORES IS NOW FOLDED OVER TOWARDS THE CENTRE

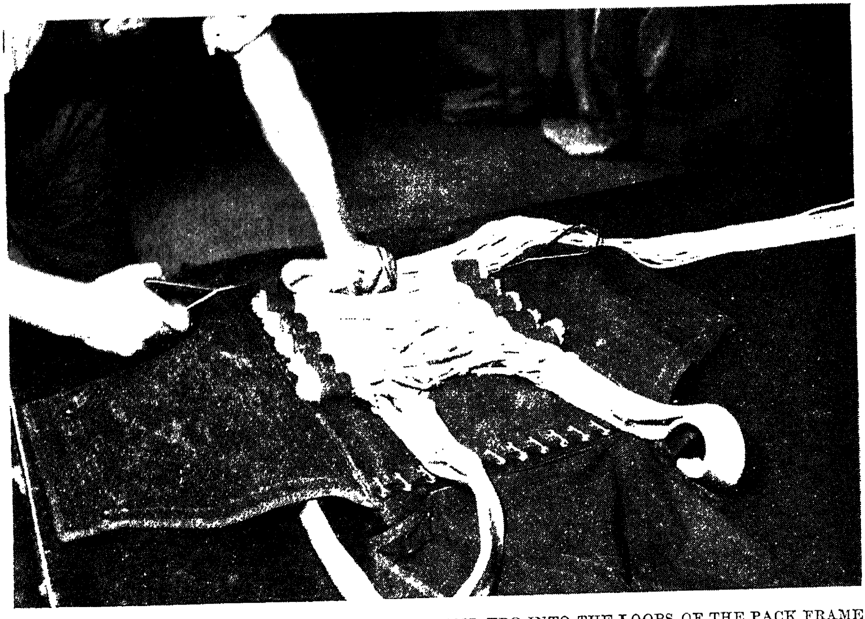


Fig. 51.—THE SHROUD LINES ARE HOOKED TO AND FRO INTO THE LOOPS OF THE PACK FRAME

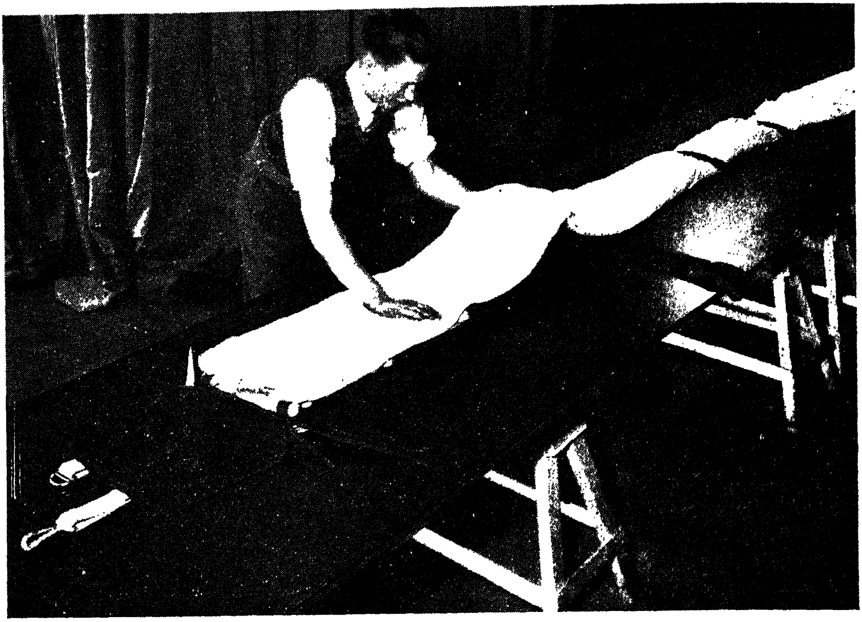
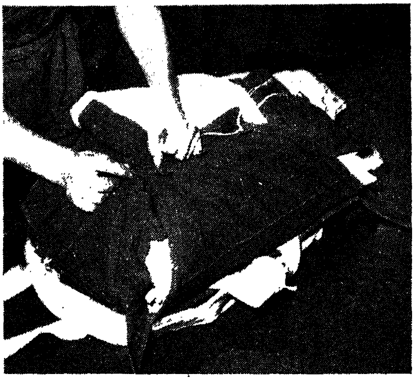


Fig. 52.—FOLDING THE CANOPY BACK AND FORE ON THE PACK

pins. Tuck down the corner flaps and pilot flaps with the packing-stick on the folded side of the pack.

Now take the pilot parachute and holding it by its shroud lines near the connecting line allow the loose silk and vanes to fall to the centre of the spring frame. Close the frame, keeping all inside, and insert in the pack



ig. 53.—PASS A PIECE OF STRONG, LIGHT CORD THROUGH EACH CONE AND PULL UP THE SHORTER OF THE TWO SIDE FLAPS

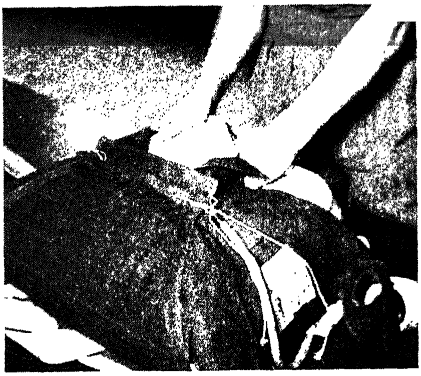


Fig. 54.—INSERTING THE PILOT PARACHUTE

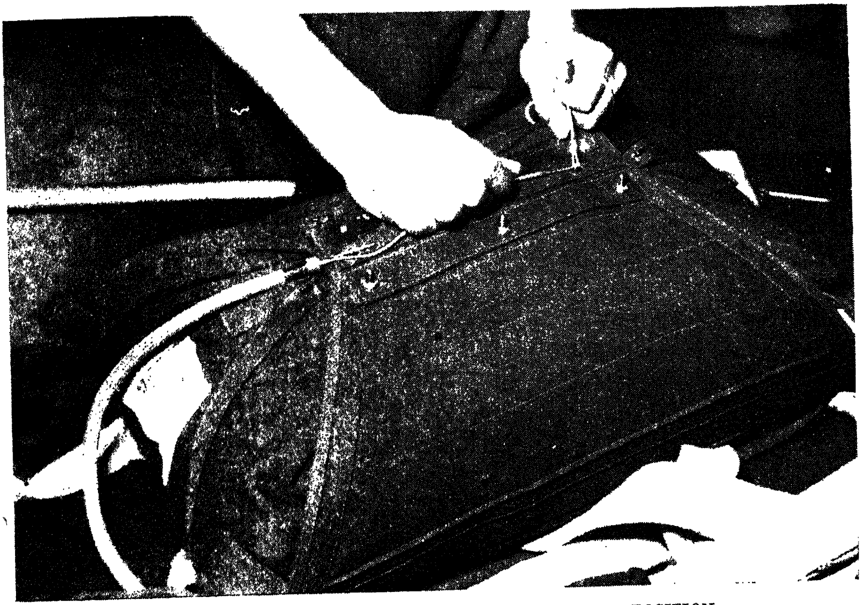


Fig. 55.—THE RIP CORD IS NOW INSERTED IN POSITION

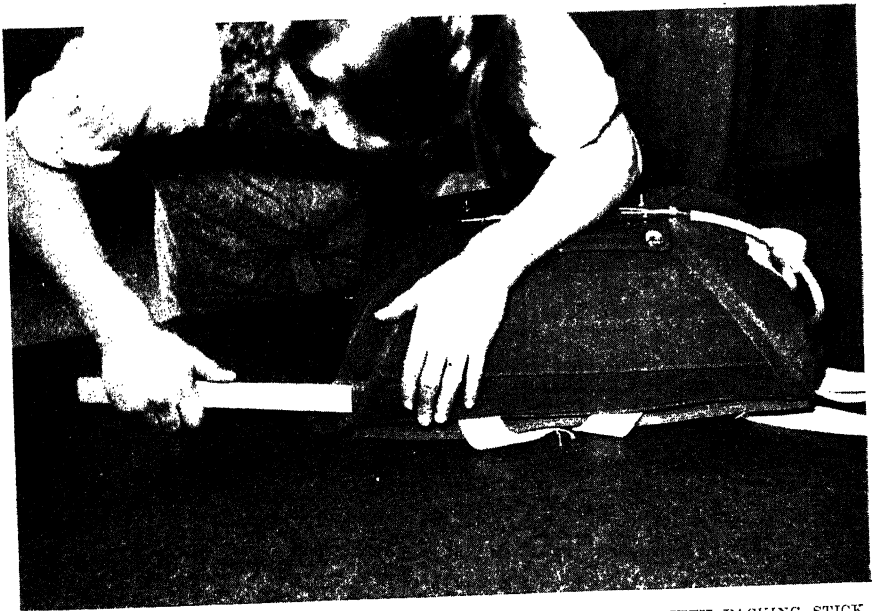
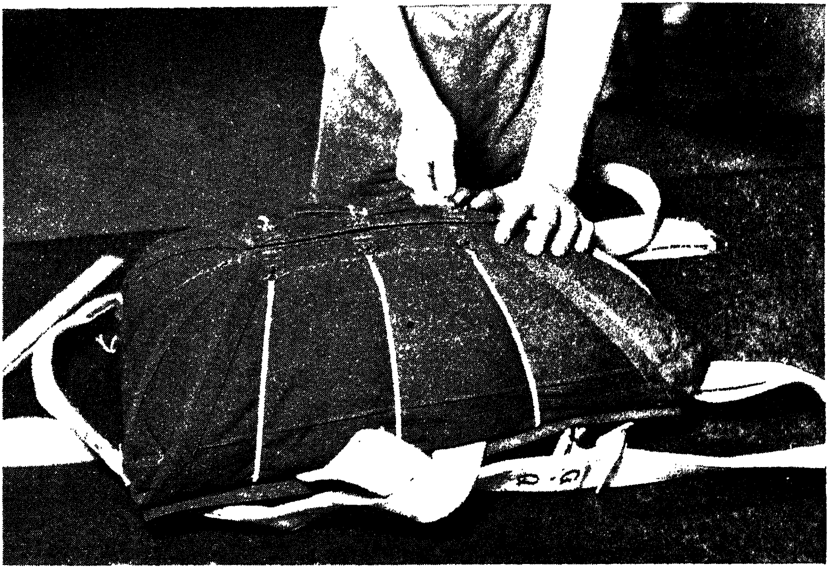


Fig. 56.—TUCKING DOWN THE CORNER FLAPS AND PILOT FLAPS WITH PACKING STICK



ig. 57.—Hooking the elastics over the completed pack

with the apex towards the rip-cord end and adjacent to the gromet and cone at that end. It should lie centrally under the steel stiffener and between the protective flaps, extending from the end flaps, but should not be allowed to pass under the cones at any point.

The other side flap may now be pulled up and, using the same strings, the gromets may be engaged with their respective cones. The rip cord can now be inserted. Place the handle in its pocket, button the cover over the rip cord on the pack and hook the elastics into position. If the parachute is stored for any length of time, it is advisable to pull the release ring and leave the parachute loose in the carrier bag.

INSPECTION, MAINTENANCE AND REPAIR OF PARACHUTES

Daily Inspection

A general inspection of the external part of the parachute should be made each day the parachute is in use. Such an inspection takes a few minutes only to complete and will disclose damage in its early stages before it has developed into a serious defect.

The following inspections must be made :

(1) See that the scarlet safety thread is intact on the locking pins.

(2) Examine the locking cones for damage and the locking pins for signs of bending.

(3) Examine the pack cover for damage such as a broken frame, contamination by acid or dampness.

(4) Examine the harness straps for general condition, especially for defective stitching or contamination by acid.

(5) See that the quick-release box functions correctly.

The following additional inspections should be made if time permits :

(6) See that the locking-cone protecting flap is fastened securely.

(7) Inspect the pack elastics and ensure that the hooks and eyes are secure.

(8) Inspect the rip-cord housing for damage and security, the ring for security in its pocket and the pocket-mouth elastic for condition.

(9) Inspect all harness fittings for damage or corrosion.

(10) Inspect seat cushion and back pad for condition and security of press studs and flaps.

Monthly Inspection

All parachutes in service, whether in constant use or held as a spare, and every parachute which has been used for a drop, must be aired for 48 hours and inspected in accordance with the following monthly inspection schedule before they are repacked. The schedule sets out the defects to be looked for and states the action to be taken to repair or remedy them. When the repair can be executed by a parachute maintenance man, full repair instructions are given ; but it will be realised that some work must be attempted only by the makers or other such experts in parachute work ; a note to this effect appears in the appropriate places.

MAINTENANCE SCHEDULE

(FOR AFTER-DROP OR MONTHLY INSPECTIONS)

The parachute must first be laid out on the packing table in the same manner as for packing, with tangles removed from the rigging lines and harness and the gore bearing the maker's name uppermost.

Special Note on Acid Contamination

Contamination by acid is probably the most serious damage which can be sustained by a parachute, because the action is rapid and, unless constant vigilance is exercised for its detection, may be far-reaching. It is of the utmost importance that acid from accumulators, etc., should be prevented from fouling parachute equipment.

Isolation of Contaminated Equipment

Any item of parachute equipment suspected of contact with acid or with contaminated parts must be isolated immediately and subjected to the test described below.

Test for Acid

Blue litmus paper moistened with water, distilled if possible, should be placed on the suspected part. Acid is present if the paper changes from blue to red.

Neutralisation

Contaminated parts should be treated with a 50 per cent. solution of 0·880 ammonia in distilled water, or, failing that, with ordinary clear domestic ammonia, the solution being applied with a swab or sponge tied to a stick, the part then being allowed to dry thoroughly.

Packs should be examined daily for signs of acid stains. These can be recognised by their putty colour, which later changes to white. They can be more easily discovered on the clean interior of a pack if the outside is at all dirty. Immediately signs of contamination are discovered the pack should be opened and isolated from the rest of the parachute, the affected parts being dealt with in the manner described above. The pack should then be set aside for ten days and subjected to inspections at frequent intervals, further signs of contamination being treated as they appear. If the damage is small, the affected part should be cut out neatly and a patch inserted; otherwise the cover should be replaced.

A main canopy or auxiliary parachute suspected of contamination must immediately be isolated and tested for signs of damage. Contaminated places must be neutralised with ammonia, or, if that is not available, the affected spots should be cut out. The parachute should be hung for ten days, contaminated places being dealt with as they appear, and at the end of that time the parachute should be returned to the makers for necessary repairs.

Should the preliminary inspection reveal no damage, the parachute should be hung and kept under careful observation for ten days. If during that period no damage comes to light, the parachute may be put back into use.

Contamination of the harness should be regarded more seriously than that of any other part of the parachute. Suspected parts of the harness should be tested with litmus paper, any affected parts being neutralised if possible or cut out; the harness is then to be returned to the makers for examination and repair as necessary.

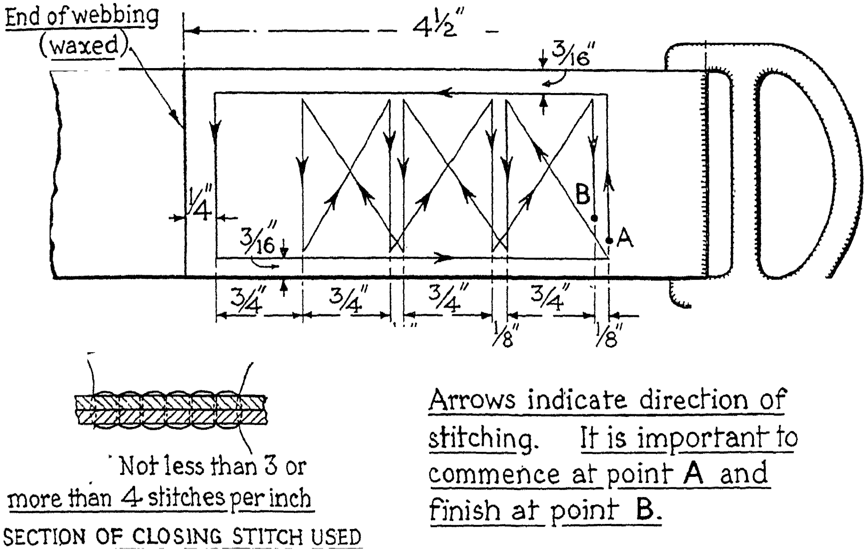
The Pack Cover

(1) Examine for acid stains, which must be dealt with in the manner described above.

(2) Holes and tears may be repaired by darning if small or otherwise by patching.

(3) Inspect the frame for fractures by feeling through the pack cover. If the frame is broken, the pack cover must be replaced by a serviceable one, the defective one being returned to the makers for repair.

(4) Examine the lug eyes for damage or insecurity. Damaged eyes must be replaced and defective stitching made good. The attachment tape on a new lug eye should embrace both sides of the flap and should be stitched round the edge and diagonally, the stitches being passed through


End of webbing (waxed)
4½"
3/16"
1/4"
3/16"
B
A
3/4"
3/4"
3/4"
3/4"
1/8"
1/8"
Not less than 3 or more than 4 stitches per inch
SECTION OF CLOSING STITCH USED

Arrows indicate direction of stitching. It is important to commence at point A and finish at point B.

Fig. 58.—Stitching diagram for sewing harness straps to D-rings

all thicknesses. The concave side of the lug eye must be towards the pack when in position over the locking cone.

(5) Burrs or roughness of the locking-cone surfaces may be rubbed down with fine emery-cloth. Badly damaged cones must be replaced.

(6) Examine pack-elastic eyes for security and renew weak stitching.

(7) Renew any slack or broken rip-cord protecting flap fasteners. Only the female portion should be replaced locally, the cover being returned to the makers for replacement of the post portions.

The Harness

(1) Starting at the upper D-ring on the left-hand side of the table, examine it for general condition and examine the harness straps for acid stains, fraying, or defective stitching, working down the main loop and back to the upper D-ring on the right-hand side of the table, inspecting this for general condition.

Broken or loose stitching may be repaired, using waxed linen thread and employing the closing stitch illustrated in Fig. 58, providing the original run of the stitching is followed. Any other repairs must be done by the makers.

If the D-rings are corroded or damaged, the harness must be returned to the makers for repair. Rigging lines must not be detached from the D-rings. Should it be necessary to separate the canopy from the harness of one of the earlier-type parachutes not fitted with detachable D-rings, the operation may be performed by cutting the stitching on the main suspension straps with a sharp knife, leaving the D-rings attached to the canopy and taking care that the webbing is not cut in the process.

To fit a new canopy to the harness, lay it out on the table as for packing, with the apex fastened to the hook or toggle at the head of the table, the gore bearing the maker's name uppermost, the vent square and the lines equally divided. Straighten out the four sets of rigging lines and lay them out on the table as though the pack were attached. Then lay out the harness as for packing, with the suspension straps one on top of the other in two pairs. Place the harness straps in position for connecting with the D-rings and keep them there with shot bags. Take the left upper suspension strap and pass its end downwards through the upper left D-ring, placing a piece of light webbing inside the turn-in of the strap for reinforcement, securing the end to be sewn temporarily by tying with cord. Then take the lower left suspension strap and pass its end upwards through the lower left D-ring, securing as before. Repeat with the two right-hand suspension straps. The harness is now temporarily attached to the canopy, and before the straps are finally stitched in position the harness must be checked to ensure that there are no twists in it and the rigging lines must be checked for sequence. This done, mark out with a pencil the lines of stitching in accordance with Fig. 58, then sew with the closing stitch as shown in the same figure, using waxed linen thread. The correct sequence of the stitching as shown must be followed, starting at *A* and finishing at *B*, not less than three and not more than four stitches being used to the inch. When this has been completed, the parachute must be laid out on the table again and the harness stitching and rigging lines rechecked.

(2) Repeat the inspection from the two remaining D-rings to the ends of the straps terminating in the upper connecting lugs. Damaged or corroded lugs must be replaced by the makers.

(3) The shoulder-spacers and adjustment adaptors on the back cross-straps should be examined, defective ones being replaced by makers.

(4) The lower front suspension straps and their connecting lugs and adjustment adaptors should then be examined and if necessary replaced, as no stitching of the harness is necessary.

(5) Check the leg loop and its adjustment adaptor and the lower belt, the harness being returned to the makers if any renewal of fittings is necessary.

(6) Inspect the waist-belt. Defective stitching in the belt or the quick-release box loop may be made good, using waxed linen thread and the closing stitch. If fitted, examine quick-release box loop for condition and security, renewing slack or broken fasteners (female portion only) where necessary. Examine the rip-cord ring pocket for security, correctness of elastic and accessibility of the ring, making any necessary repairs or replacements.

(7) Check the rip-cord housing for the following defects :
- (*a*) The braiding for fraying ;
- (*b*) End ferrules for secure attachment to both internal coil and braiding ;
- (*c*) Fracture of the internal coil ;
- (*d*) Crushing of the housing and sharp bends ;
- (*e*) Defects in the copper wire reinforcement at the lower end ;
- (*f*) Security of attachment to pack cover and harness. Renew stitching where necessary.

If any of the defects (*a*) to (*e*) are found, the housing is to be replaced.

The Quick-release Box

Examine this for defects, testing for easy working, each plunger spring being tested separately by inserting the harness connecting lug. The locking plungers or any of the springs may be replaced, but other defects must be repaired by the makers, a serviceable box being substituted in the meantime.

The Rip Cord

(1) See that the locking pins are not bent or rough, that the soldered joints are sound and that the strands of the cable are not frayed. If any of these defects is found, replace with a new rip cord.

(2) Examine the cable for rust ; if rust is present, remove it with an oily rag and coat with a rust preventative.

The Back Pad

Repair small holes or tears and replace defective stitching. The pad should be returned to the makers for replacement of defective press studs.

The Seat Cushion

Repair holes or tears and replace defective stitching. If press studs are defective, fit a new seat cushion and return damaged one to the makers for repair.

The Main Rigging Lines

(1) Check both D-rings on the left-hand side of the table for corrosion of the rings under the knots. Ensure that the knots are tied correctly and that the zigzag stitching is correct. If defects are disclosed in the attachment of the lines to the rings, the canopy must be returned to the makers for repair.

(2) Arrange all rigging lines on the left-hand side of the table side by side between the first and second fingers of both hands and examine the lines, about two feet at a time, up to the periphery of the canopy, turning them over so that both sides are seen. Small loops projecting from the surface must not be cut off, but should be pushed back into position with a blunt pin. The lines must be of uniform length ; if frayed or stretched

lines are found, the canopy must be returned to the makers for repair. Knots must on no account by made in the lines. Defective lines must be marked with labels for easy indentification before return to the makers. Return from the canopy to the D-rings, inspecting in the same way the lines on the right-hand side.

The Main Canopy

(1) The canopy being laid out as for packing, examine the attachment of the two rigging lines to the topmost gore to ensure that the zigzag stitching is intact and the seam is undamaged. Repeat with the other gores as they are reached in the course of the inspection. If any defects in the attachment of the lines are revealed, the parachute must be returned to the makers for repair.

(2) Starting at the periphery and working carefully upwards towards the apex, examine the gores for :

- (*a*) Acid stains ; these should be dealt with in the manner described previously.
- (*b*) Holes and tears ; by taking the two rigging lines attached to the gore under examination, one in each hand, and flicking them up and down in order to trap air underneath the gore, the holes and tears will be revealed and any creases will be straightened out. Repair of these defects to be undertaken by makers ;
- (*c*) Broken or loose stitching in seams ; as each panel seam is reached, it should be pulled and examined for signs of breaking stitches. Return to makers for repair ;
- (*d*) Stains on the silk ; stains of a harmless nature such as those caused by contact with grass or earth should be lightly brushed and allowed to remain. No attempt should be made to wash or clean them off with any solvent. Canopies stained with injurious substances such as grease or oil should be returned to the makers for repair ;
- (*e*) Strains in the silk ; even in new parachutes slight relative displacement of the threads may occur ; but provided the threads are not too widely separated and are not broken, repairs are unnecessary and the parts should be left alone. On no account should such parts be pulled, as this is likely to set up a bad strain, which must be repaired. Where definite weakness is suspected, the canopy should be returned to the makers for examination and repair if necessary.

(3) Examine the attachment of the rigging lines to the apex seams and see that the zigzag stitching is intact and the seam undamaged. The rigging lines attached to the gores should be examined in accordance with the procedure for rigging lines, and described above. Defects in the attachment of rigging lines should be rectified by the makers.

Repeat with all gores.

The Auxiliary Parachute

(1) Open the auxiliary and inspect each gore in a manner similar to that in which the main canopy was inspected. Defects are dealt with in the same way, but small holes or tears such as those caused by the frame ribs wearing through may be repaired by darns not more than ¼ in. in diameter. Auxiliaries damaged to a greater extent must be returned to the makers for repair. Ensure that the peripheral seam is not damaged and examine the rigging-line attachments for security.

(2) Examine the rigging lines for defects in the same way as the main rigging lines are examined. Repairs or renewals of lines are not to be undertaken locally; the auxiliary must be returned to the makers. Examine the serving off of the end loop for condition.

(3) Examine the auxiliary extension piece and ensure that the bowline knot at each end and the zigzag stitching at the main canopy end are secure. If a defect is disclosed, the main canopy must be returned to the makers for repair.

(4) Examine the inside of the canopy for signs of the frame ends pushing through the reinforcing tapes, holes in which may be patched or darned. Defective or broken springs may be detected by opening and closing the frame vigorously several times. If defects are disclosed, such as loss of temper, etc., a new auxiliary spring frame should be fitted. The spacer should be examined for condition; if it is necessary to fit a new one or to resolder, the resoldering must be done in the following manner: Before soldering, drill the spacer tube ¼ in. from each end with four ⅛-in. holes, two at each end where the clips are located. If the solder flows properly when the joint is being made, it will then exude from these holes. After soldering, the joint must be thoroughly cleaned by immersion in boiling water to ensure that all traces of flux and dirt are removed. Sharp projections must then be smoothed down.

GENERAL

Treatment after Immersion in Water

Fresh Water.—If the parachute should accidentally be soaked in fresh water, it must be rinsed in a tank with several changes of clean fresh water and then be allowed to dry out. The silk must on no account be wrung or twisted. If the parachute has been immersed for a considerable period or on several occasions, so that there is reason to suspect deterioration of the fabric, the parachute should be returned to the makers for drop testing.

Sea-water.—In the event of immersion in sea-water, great care must be taken to remove all traces of salt in the washing. The parachute should first be immersed in clean fresh water for two to three hours to ensure penetration to the thicker parts of the harness; this soaking should be followed by four changes of clean water, the various parts being squeezed repeatedly during these processes. Salt which remains in the webbing is liable to set up corrosion of the metal fittings, even if these are of stainless steel. When the parachute has been dried out, it must be returned to the makers for drop testing.

Log Book

Whenever a new parachute is brought into use, a log book should be assigned to it, in which should be entered full details of all tests, periodical inspections, repairs, replacements of parts, repackings, etc. The log book will then afford a complete history of the parachute and will be a valuable contribution towards efficient maintenance.

NOTES ON THE USE OF PARACHUTES

Experience in the use of parachutes in this and other countries has established a technique of parachuting which should be studied and practised by all who fly. The principles which have been evolved will enable the correct decision to be made when a critical situation arises.

A parachute descent may be divided into the following phases :

1. Getting clear of the aircraft.
2. Releasing the parachute.
3. Controlling the parachute during descent.
4. Alighting.

When a jump has been decided upon, all equipment such as telephone leads, oxygen leads, etc., must be disconnected as close to the body as possible to minimise the risk of entanglement with the aircraft. The parachutist should then leave the aircraft in the shortest possible space of time. The method of accomplishing this will depend upon the design of the aircraft and the attitude in which it is when being abandoned. The following methods will cover most conditions and will serve as an indication of the factors which have to be considered in such a situation.

Normal Gliding Attitude

The method recommended for leaving an aeroplane in a normal flying or gliding attitude is a head-first dive over the side by the shortest possible route. This offers the best chance of avoiding the tail structure *en route*.

When an aeroplane is in a steep dive, there is a tendency for the pilot to fall forward into the dashboard. This is normally resisted by his belt or shoulder straps ; he should bear this in mind and guard against it before releasing them. In these conditions the aeroplane is approaching the ground very rapidly and it is therefore important to get clear with the utmost speed.

Spin

Experiments have shown the best way of getting clear of an aeroplane in a spin is to dive head first over the side of the aeroplane nearest the axis of the spin. Difficulty may, however, be experienced in so doing, as centrifugal force tends to press the body to the floor of the cockpit. In these circumstances the best method to adopt is to get both arms over the inner side of the cockpit and then gradually force the chest over, when, the centre of gravity of the body having gone over, the rest can be left to centrifugal force.

Inverted Spin

In this case, centrifugal force acts in such a way as to throw the occupants out of the cockpit as soon as safety belts or harnesses are undone. Passengers and crew should make a point of ensuring that the quick releases on safety-harness anchorages can be easily released when under tension, otherwise they may find themselves suspended from the floor of the cockpit and unable to release themselves.

Releasing the Parachute

A manually operated parachute should not be released until well clear of the aircraft so that there is no possibility of entanglement. Release should be effected by a sharp jerk on the rip cord, pulling it clear of the housing. A sharp jerk is more effective than a steady pull. The arms should then be folded across the chest until development is complete. This ensures the harness being kept in the right position during the initial stages of the opening. Should the rigging lines then be found to be twisted, an effort should be made to untwist them by rotating the main suspension straps in the appropriate direction.

During descent limited control is possible by manipulation of the main suspension straps. The forms of directional control are turning and side slipping.

Oscillation

Although the tendency to oscillate is reduced by the presence of the vent at the top of the canopy, persistent oscillation may occur as a result of air disturbances. There are two recognised methods of checking this. Firstly, by pulling down firmly on the rigging lines from the high side of the canopy in both directions of the oscillation. The second method is to pull down simultaneously upon two sets of opposing lines. This forms two lobes in the canopy on opposite sides, which damps out the oscillation by the changed conditions of stability. As soon as oscillation stops, the rigging lines should be released, permitting the canopy to return to its normal shape.

Side Slipping

It may appear during a descent that there is danger of alighting on trees, buildings, high-tension cables or other obstructions; in these circumstances it is possible to change the path of descent by side slipping.

To effect this, the rigging lines on the side to which it is desired to move should be pulled down. This spills air from the opposite side and produces a resultant air pressure on the canopy which moves it in the required direction. In a violent side slip, the canopy may appear to collapse, but this need occasion no alarm, as it will quickly recover when the rigging lines are released. Spilling the air increases the rate of descent and side slipping should not be continued near the ground. The parachutist should aim to slip to the side of an obstacle or to land short of it. Attempts to side slip down wind over it will not be successful, as the greater rate of descent more than counteracts the increase in horizontal speed. The increased rate of descent may be used to prevent the parachutist being carried on to unsuitable ground in a high wind. He should of course side slip into wind further to minimise its effect.

Turning

It is desirable that a parachutist should face down wind in the direction of travel in the early stages of a descent. He will then be able to study the ground on which the landing is to be made. Furthermore, it is desirable to alight facing down wind, as then there is less likelihood of being dragged along the ground by the parachute.

To turn the parachute in the air, a main suspension strap should be grasped on that side of the canopy towards which it is desired to turn and the periphery pulled down about 3 ft. Then, with the other hand a suspension strap on the other side should be grasped and, without pulling down, a vigorous twist should be given to the canopy in the direction of the desired turn. When the swing of the arms is complete the canopy is released and the body follows its movement. Turning should not be attempted near the ground, as in this case, too, the rate of descent is increased.

Alighting on Land, Normal Conditions

The landing should, if possible, be made facing down wind. On approaching the ground the sitting position should be retained and the muscles relaxed. No attempt should be made to take the shock of landing by stiffening the muscles. The suspension straps should be grasped as far as possible above the head, and at the moment of impact the body should be given a hard pull upwards to assist in absorbing the landing shock. The body should be allowed to sink to the ground and if necessary roll over.

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